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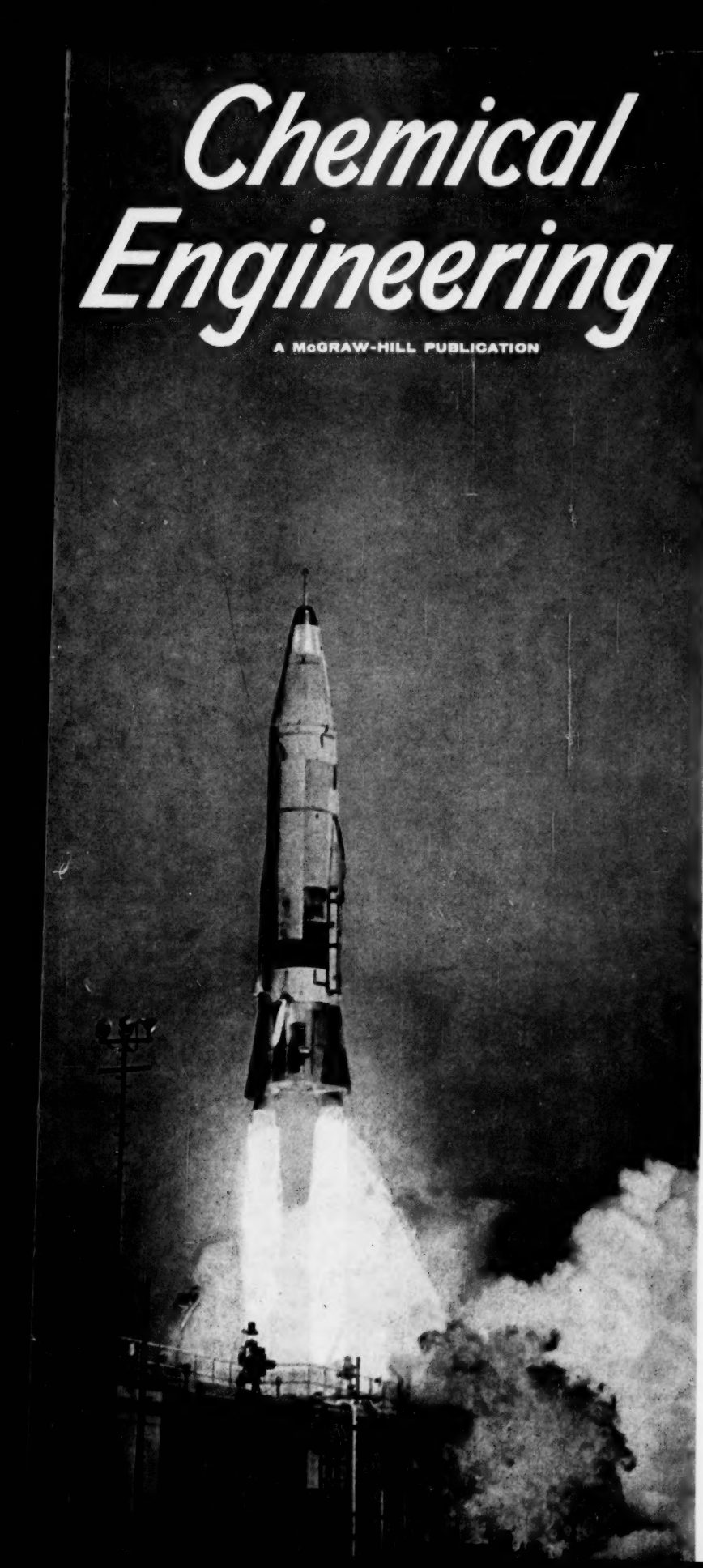

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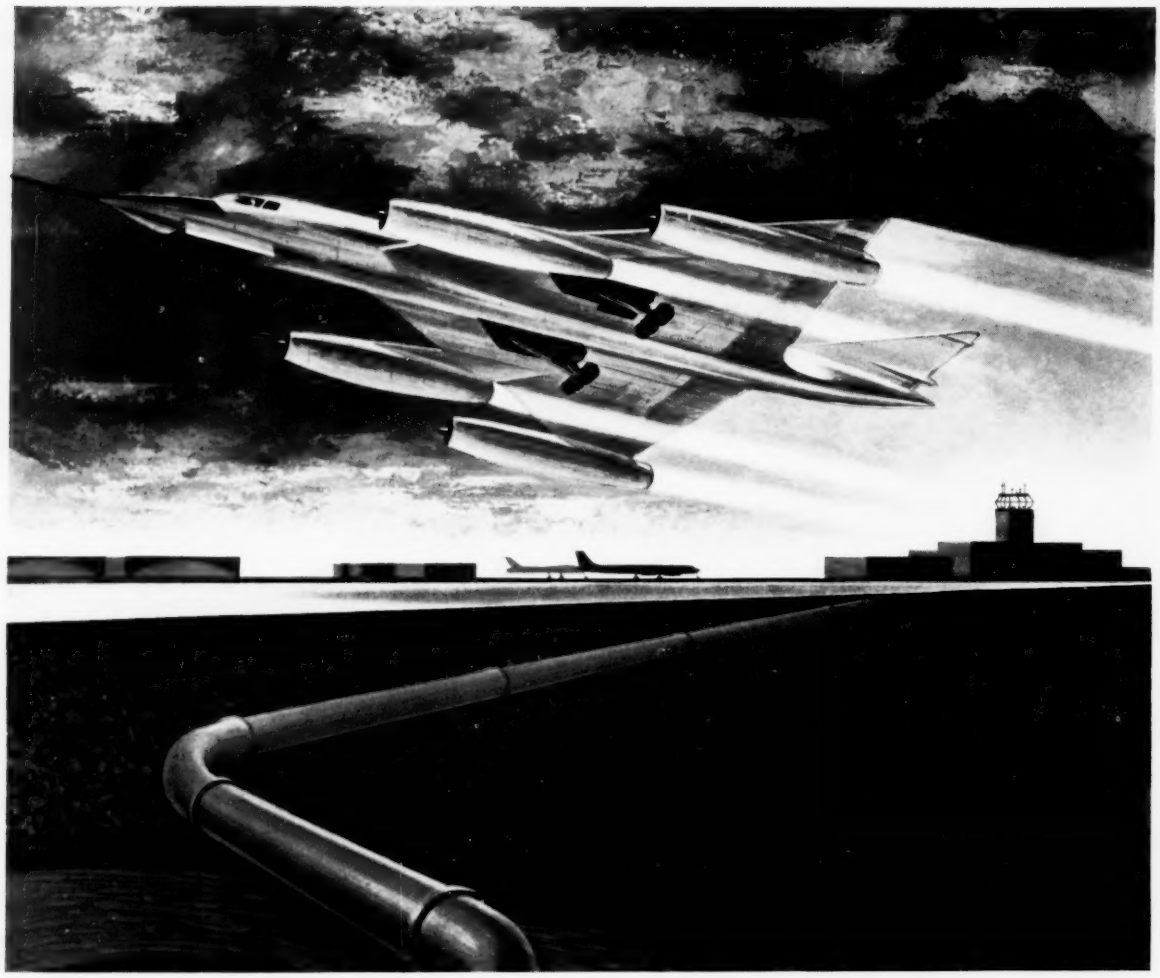

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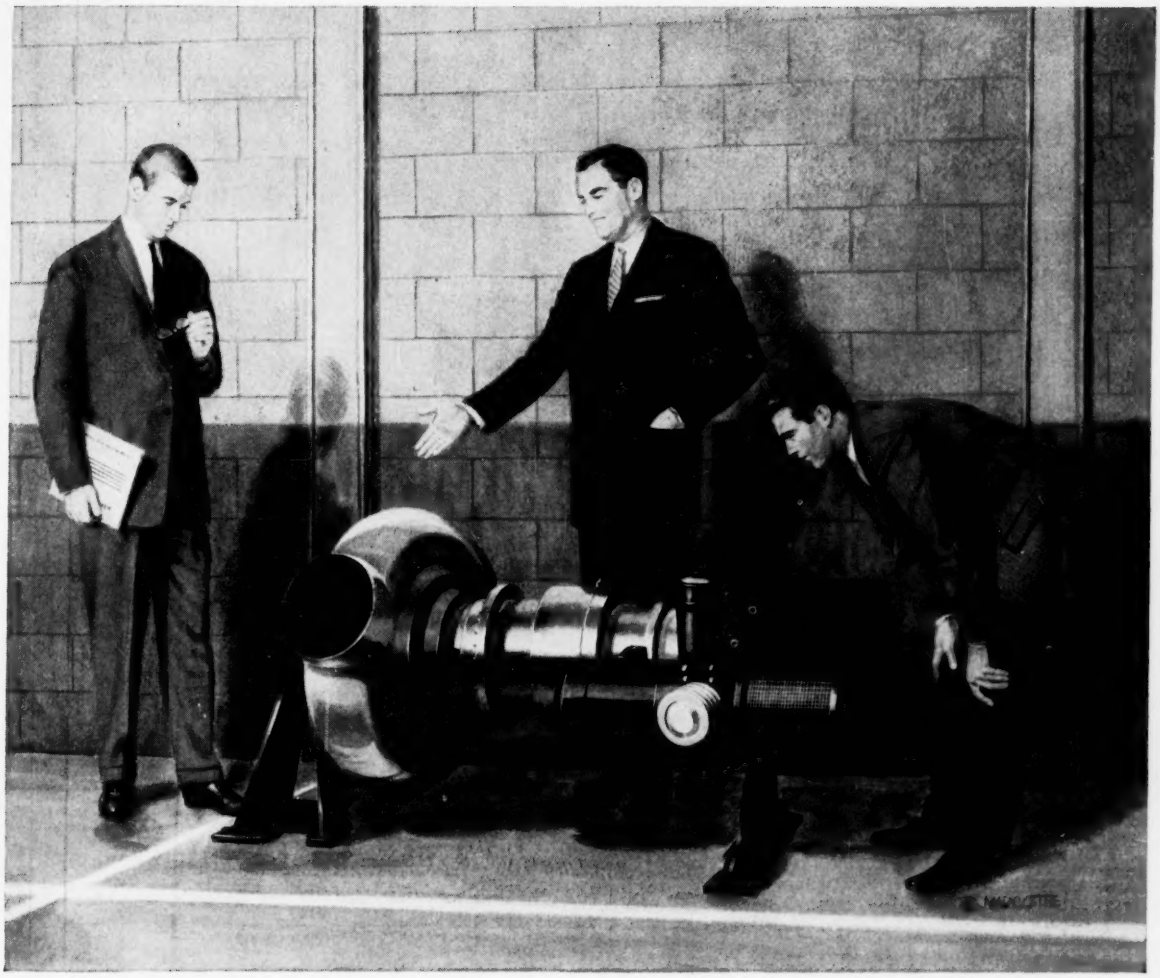

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Today, proven-in-service Solar gas turbines—ranging from 50 to 1100 hp—are creating new standards of performance and reliability. As propulsion units for boats, as a dependable power source for electric generators, as high-efficiency pumps and in other applications... Solar gas turbines are saving time and money for hundreds of satisfied users. For a new gas turbine brochure, write to Dept. G-154, Solar Aircraft Company, San Diego 12, Calif.

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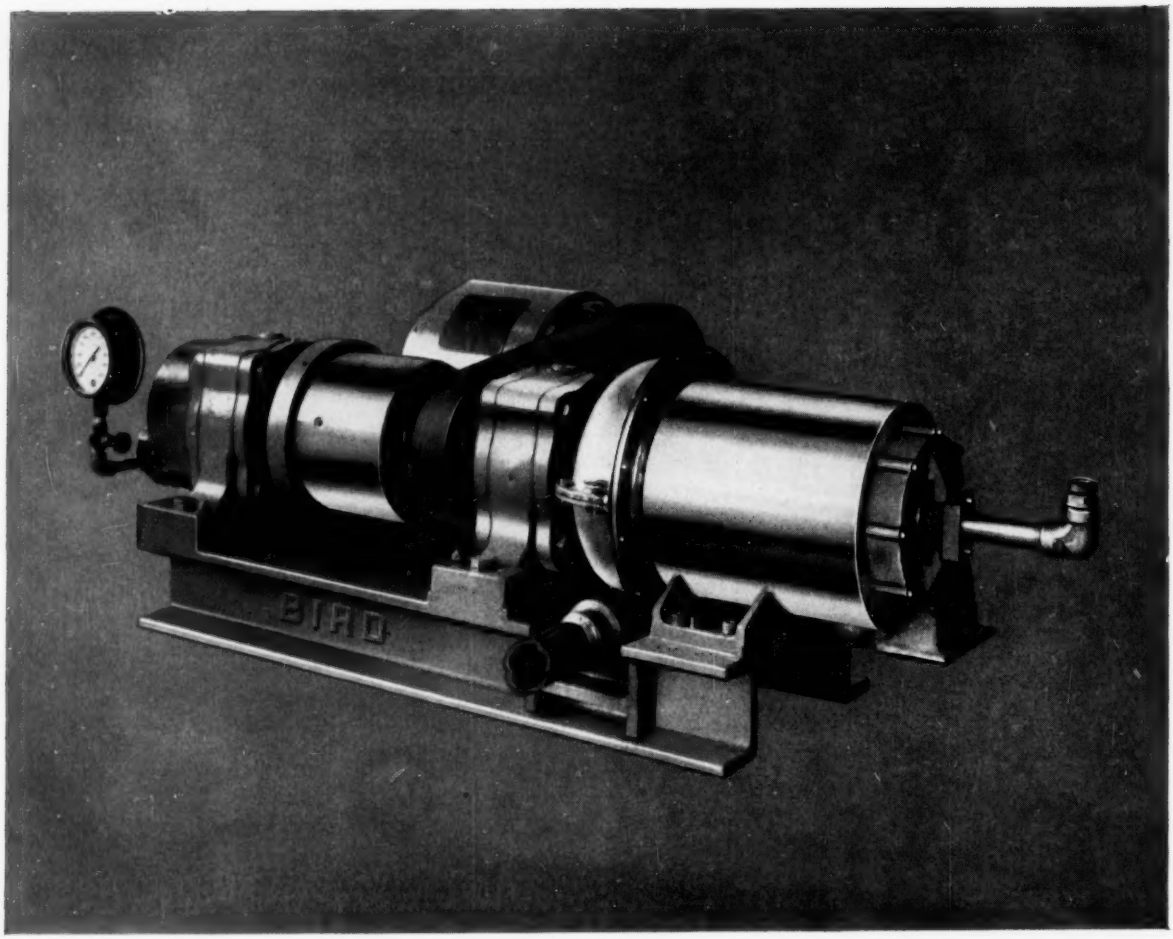

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November 2, 1959 **Chemical Engineering** Vol. 66 No. 22

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*FREE—for your files—Check Reader Service postcard (p. 145) for an extra copy of this guide to chemical company performance.

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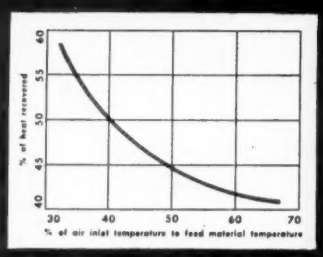
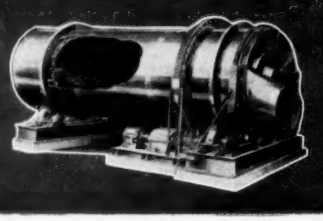
LINK-BELT Roto-Louvre coolers SAVE UP TO 60%* OF WASTE HEAT

Shown is the Link-Belt Roto-Louvre cooler with super heat recovery. A single-pass arrangement is available for situations not requiring such a high heat return.

1. Material enters at 1800 F.
2. After first pass over material, air temperature is 700-800 F.
3. After second pass, air temperature is 900-1000 F.



* All figures used here are relative. Actual results depend on such variables as material size, specific heat, temperature range, duct losses, air volume requirements, etc.



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The higher cooling efficiency of Link-Belt Roto-Louvre assures a higher return of heat every time. And if desired, air can be passed over the material a *second* time, permitting heat recoveries up to 60%.

The Roto-Louvre is the *only* cooler that produces such a uniformly cooled product. And because material rolls gently over itself, no degradation occurs from lifting and cascading. This same gentle rolling action also prevents abrasion to the louvres.

The inherent superiority of Roto-Louvre design also produces economies of installation and maintenance. The unit occupies up to 50% less space than other types of coolers. In addition, it is mounted parallel on its trunnions—won't become misaligned.

For a complete report on the cooling efficiencies of Roto-Louvre, contact your Link-Belt office.

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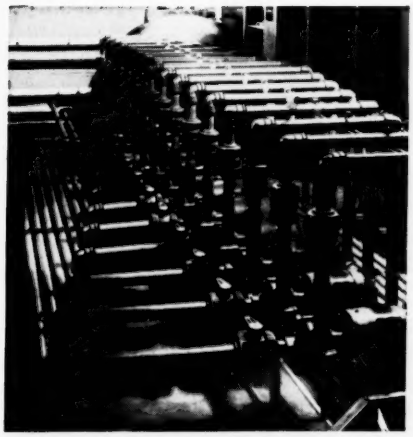
PLASTIC PIPE

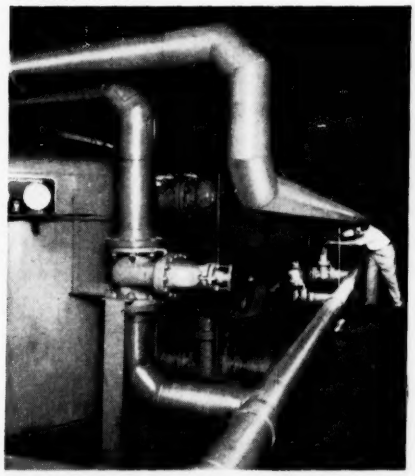
no rust, no rot, no corrosion...

no other pipe does the job so trouble-free

so permanently, at so little cost!



KRALOY PVC Plastic Pipe with plastic valves and fittings installed in the photographic laboratory at the U.S. Air Force Missile Test Center, Patrick AFB, Florida. KRALOY is unaffected by most all common acids.



Swimming pool water filters as installed at one of the leading Miami Beach hotels using 6" KRALOY PVC Plastic Pipe. Note solvent-welded joints to fit all requirements of the installation.

Industry's toughest piping problems are being solved faster, more easily and more economically than ever before by today's great trend to KRALOY Plastic Pipe. Engineers and contractors have found that KRALOY PVC Plastic Pipe meets virtually every piping need and solves corrosion and maintenance problems that no metal pipe or other materials can handle.

Unaffected by electrolysis, highly resistant to salt water scale and most all common acids, KRALOY not only avoids rust-outs and metal deterioration failures—but most important in meeting budget specifications, it is cheaper to install and maintain.

Light in weight (⅛ that of steel), KRALOY's ease of making joints and bending simplifies transportation, handling and laying—*saves up to 50% on installation costs!*

SMOOTH WALLS = HIGHER "C" FACTOR, FASTER FLOW

Quality protected by continuous laboratory control—today's KRALOY Pipe provides both normal and high impact strength. Precision extruded, KRALOY'S smooth, highly polished mirror-finish walls reduce friction, permit faster, freer flow that delivers up to 20% greater volume than metal pipe... even permits use of smaller pipe sizes! And KRALOY *permanently retains* these superior flow qualities. Underground or aboveground—for liquid or use as conduit—when your requirements call for long life, corrosion and trouble-free pipe—specify KRALOY PVC Plastic Pipe. Available in all sizes from ¼" to 12" with plastic valves and fittings.

Send for KRALOY's new **FREE** 36 page Technical Handbook on PVC pipe... filled with information including flow charts and a corrosion resistance chart covering more than 160 acids. **Kraloy Plastic Pipe Co., Inc., Dept.ChE-11, 4720 East Washington Boulevard, Los Angeles 22, California.**

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Foxboro Pneumatic Consotrol Control Panel at Hercules Powder Company, Burlington, N. J. This Foxboro panel is arranged in a 180° arc so operators can spot warning lights from any position. Continuous air purge in control room eliminates need for explosion-proof electrical switches, alarms, and signal lights.

Hercules Powder Company reports:

175 Pneumatic Consotrols* on stream three years *"—not a single unscheduled shutdown"*

At the Hercules plant in Burlington, New Jersey, they're producing millions of pounds of di-methyl terephthalate a year. Foxboro Pneumatic Consotrol indicators, recorders and controllers provide the instrumentation for the entire multi-million dollar plant.

Hercules operators find their Consotrol instruments perfect for the job. They like the ± 1% accuracy of control they get. What's more, they're able to service an M/58 Consotrol Controller — even to a complete disassembly — and have it back in operation in just a few minutes. And they can convert a Consotrol indicator to a recorder by simply inserting a chart drive mechanism.

Get the full story on these low-maintenance, accurate Consotrol Recorder-Controllers before you design your next control system. Write for Bulletin 13-18 — it has all the details. **The Foxboro Company, 3611 Neponset Ave., Foxboro, Mass.**

*Reg. U.S. Pat. Off.

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pneumatic Consotrol instrumentation

Harbison-Walker Specialized Refractories withstand severe conditions . . .

Longest service and lowest maintenance costs largely depend upon the best selection and use of refractories. The schematic drawing here shown, illustrates typical brand selections for severe conditions in various sodium silicate furnaces. The brands indicated for each location possess the chemical and physical properties needed for longest service for that particular position. Other Harbison-Walker brands provide alternate selections for less severe conditions.

Harbison-Walker produces all the different kinds of refractories needed to most closely equalize each other in service. Their proper selection and use assures longest campaigns, and minimum overall costs, in furnaces producing various classes and composition ratios of alkali to silica.

Your experience and comprehensive knowledge of your operating conditions, and the availability of these quality-controlled refractories of known properties and performance records, affords the means of selection for the best results.

Harbison-Walker freely offers the cooperation of the Technical Service Department in choosing the refractories for greatest economy in each specific application.

Some HARBISON-WALKER BRANDS especially suited for the rigorous conditions of sodium silicate furnaces

FORSTERITE I is the magnesium silicate checker brick which continues making splendid records. Also included in the category of basic refractories for use in regenerators are several periclase compositions having bonds of forsterite, magnesium-aluminate and duo-spinels.

DIALITE DOT used for many years in crowns, is regarded as standard at many plants.

H-W MULLITE serves with excellent results in the upper side walls and crowns of metasilicate furnaces.

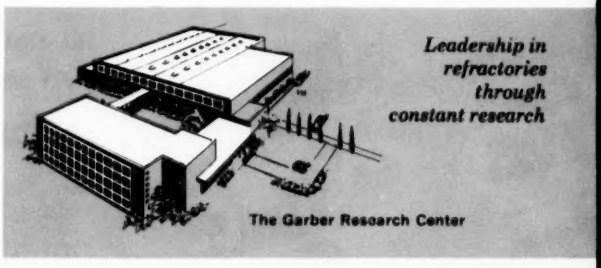
KORUNDAL DASH consists of corundum bonded with mullite and has a total alumina content of 90%. It is used with benefit, surpassing many other refractories, in port necks and paving, jambs and sills and around tapping holes.

VARNON D AND VARNON S are special dense, extra hard-fired, super-duty fireclay brick, fully stabilized in their alumina content to mullite, with residual cristobalite. It is exceedingly low in porosity and permeability. Its properties commend it for complete side walls of furnaces producing ortho-sodium silicates.

OTHER PRODUCTS Among the complete range of refractories widely used in this industry are Harbison-Walker brands of high duty fireclay brick and super-duty fireclay brick. These may be furnished from any one of many locations, thus facilitating delivery time, and reducing transportation costs.

Harbison-Walker insulating fire brick and other insulating materials of all classes serve advantageously in various applications of sodium silicate furnaces.

Harbison-Walker makes the complete range of castable refractories, a number of which are in reality specialized for use in certain parts of sodium silicate and glass furnaces. They provide a selection of materials as serviceable as prefired refractories, for monolithic constructions of a difficult or complex design.



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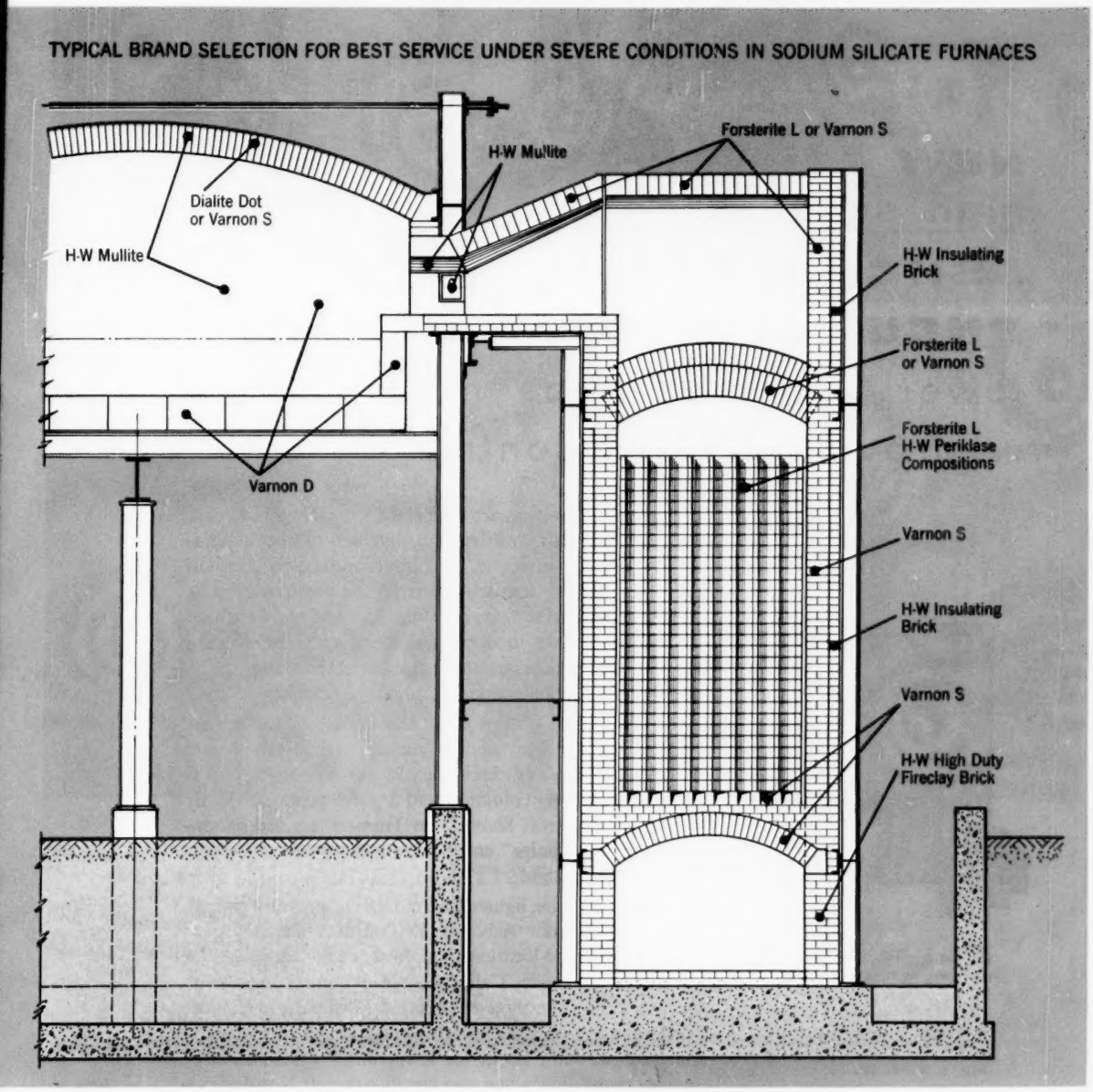
assure longest service and lowest cost


TYPICAL BRAND SELECTION FOR BEST SERVICE UNDER SEVERE CONDITIONS IN SODIUM SILICATE FURNACES
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H-W Mullite
Dialite Dot or Varnon S
H-W Mullite
H-W Insulating Brick
Forsterite L or Varnon S
Forsterite L H-W Periklase Compositions
Varnon D
Varnon S
H-W Insulating Brick
Varnon S
H-W High Duty Fireclay Brick

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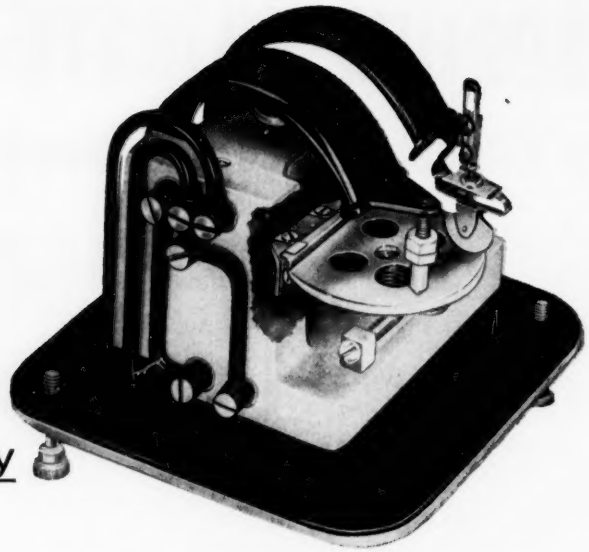

NEW high sensitivity ASHCROFT PNEUMATIC TRANSMITTERS

lower costs...reduce maintenance ...provide tighter control

Ashcroft Non-Indicating Pneumatic Transmitters are made in pressure and temperature types, each in regular and short span. Operation is on low-pressure air: output range, 3-15 psi or 3-27 psi.

These new transmitters are designed around (1) a powerful, efficient relay with sensitivity high enough to operate controllers, and (2) a simple, dual Bourdon tube motion-balance system. High sensitivity permits the use of narrowest proportional band settings on controllers and allows instant controller response to deviations from set point. With a shorter transmission lag, automatic corrective action starts before the deviation becomes critical.

In manual control systems, these new Ashcroft Transmitters (teamed with suitable receivers) make it practical to operate boilers at the most efficient level. In wet processing operations, fractionating columns yield a purer product. Highly suppressed Ashcroft Short Span Transmitters are so sensitive they can "judge" entire control loops and detect any errors in the system.

Basically a 6" cube, lighter than most 8½" pressure gauges, these climate-proof Ashcroft Transmitters are simple to install in cramped locations, are most readily accessible for adjusting or service. Calibration is extremely easy, with linearity checking entirely eliminated. Most parts in all types in the line are interchangeable. Ask your nearby Ashcroft Gauge Distributor about the lower initial costs and other savings that follow when you install Ashcroft Non-Indicating Pneumatic Transmitters. Send for Bulletin 361.

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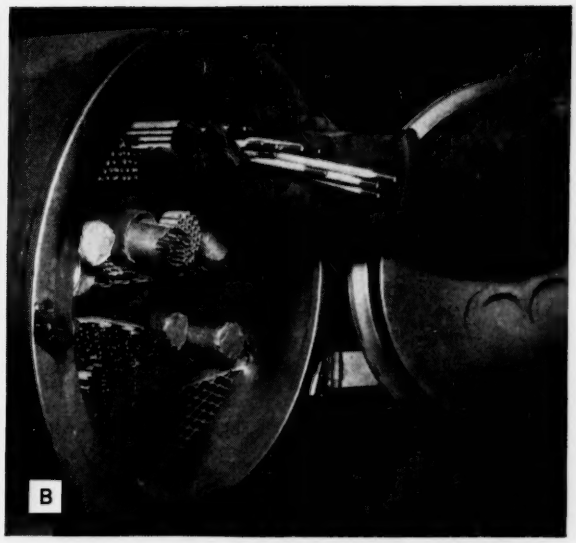

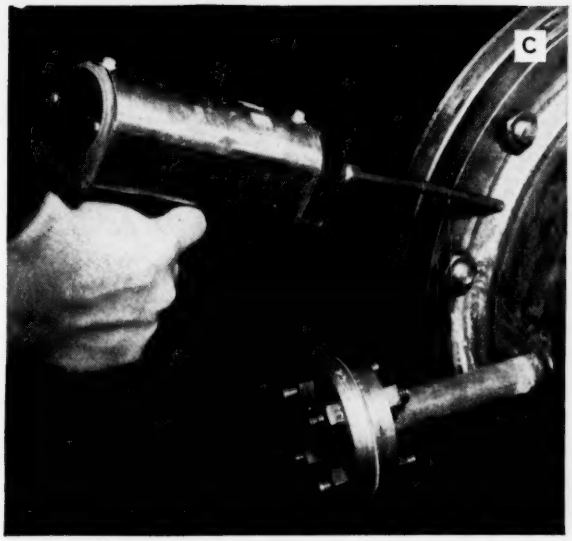

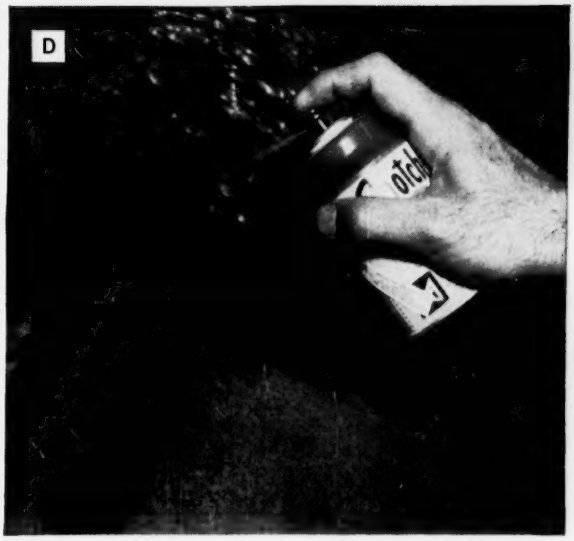

Modern techniques bring new benefits

Whatever is new in metallurgy, welding, or testing is sure to absorb the attention of Downingtown experts—especially when it helps us produce better processing equipment for you. Here are some of the modern techniques you would see on a trip through our shop. Write for handy index to the ASME Code.

A **Skin-deep**—When paint thickness is vital to product protection against corrosion, this instrument tells us exactly how thick the paint application is.

B **Fresh from the oven**—Heated to 250°F to drive out water vapor, these welding electrodes won't contaminate weld metal or adjacent plate with water-released hydrogen.

C **Sniff! Sniff!**—No leaks here... if there were, the Halide leak detector would react fast as it sniffs the seams and joints of a vessel pressurized with gas.

D **A penetrating analysis**—Special dye, sprayed on weld after back-chipping, reveals microscopic cracks so they can be eliminated before weld is completed.

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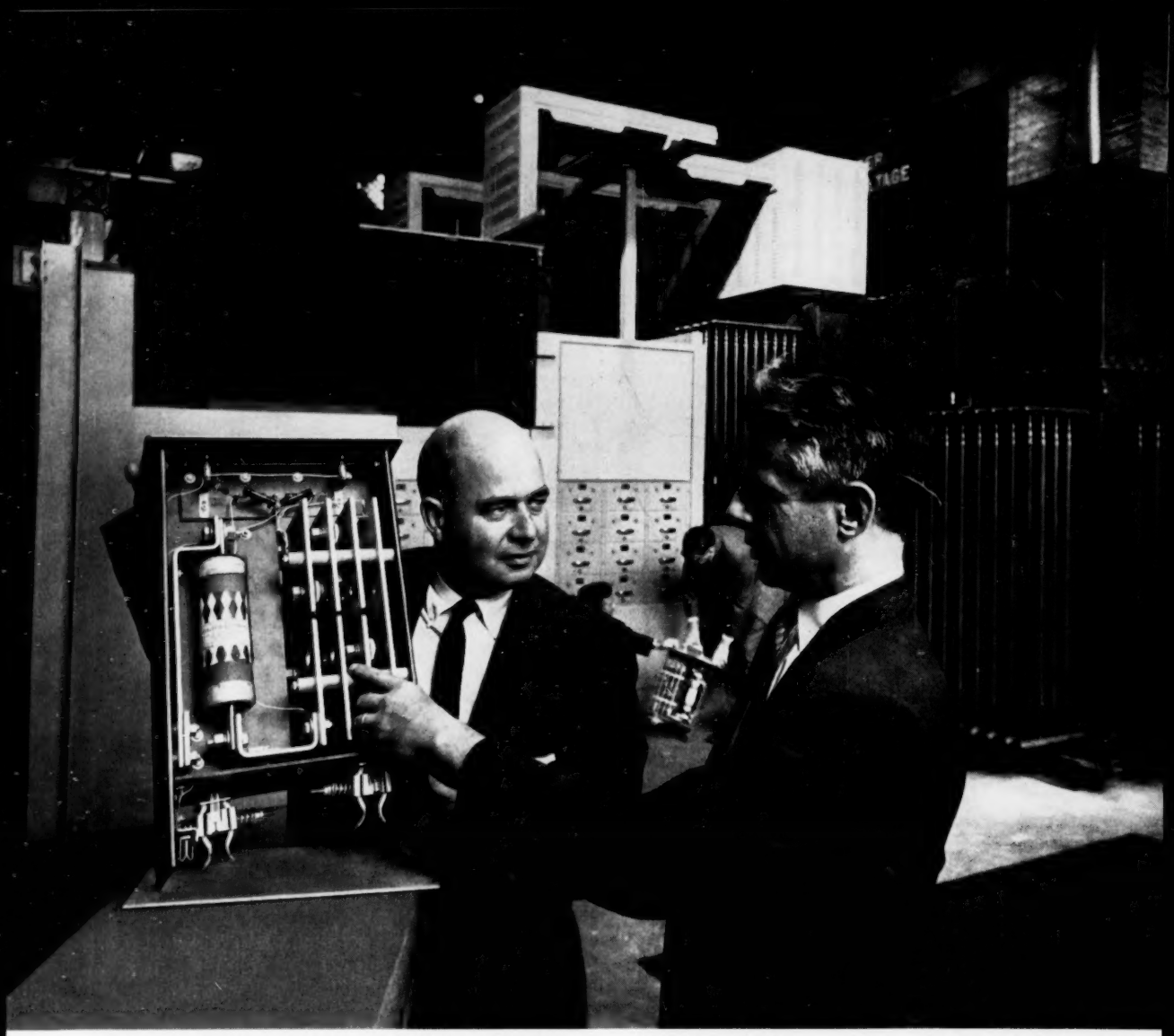
CONTAINERS AND PRESSURE VESSELS FOR GASES, LIQUIDS AND SOLIDS

DOWNINGTOWN IRON WORKS INC. Hackney



HEART OF THE NATION'S LARGEST SILICON POWER RECTIFIER INSTALLATION is the silicon rectifier tray, shown here being discussed by W. S. Heston (left), General Electric, and Donald E. Springer, Chief Engineer for the Hooker Chemical Corporation, Niagara Falls, New York.

Built by General Electric for Hooker Chemical Corporation

Nation's Largest Silicon

SILICON RECTIFIER EFFICIENCY IMPROVES POWER OUTPUT, REDUCES EXPENSIVE DOWNTIME ON CONTINUOUS PROCESS LINE

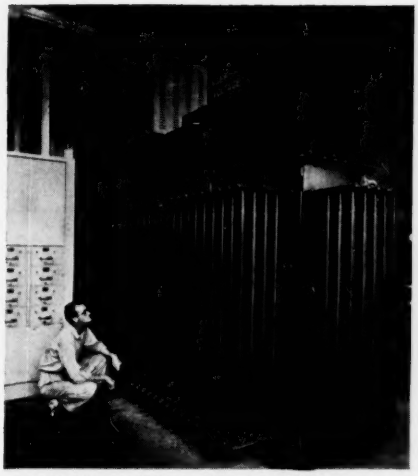
As the trend in the Northeast from 25-cycle to 60-cycle power gained momentum, Hooker Chemical Corporation had to modernize its power conversion system. As a result, Hooker's Niagara Falls, New York, plant installed the largest silicon power rectifier system in the nation—with equipment completely system-engineered and built by General Electric.

The four 96-tray silicon rectifier circuits of the system were designed to replace 12 rotary convertors. The rectifier system services 55 per cent of the plant's Hooker Type S cells, which produce chlorine, caustic soda and hydrogen, and 24 per cent of Hooker's power consumption at Niagara.

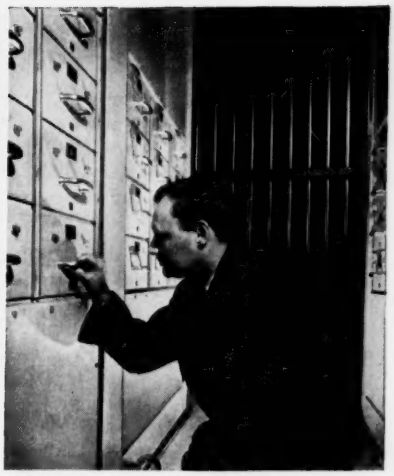
For this continuous process line, operating 24 hours a day, seven days a week, the basic simplicity and efficiency of the General Electric silicon rectifier system was explained this way by Donald E. Springer, Hooker's chief engineer: "The silicon rectifier system will save space and lower maintenance and operating costs appreciably. Replacement of the silicon rectifier tray is a matter of seconds, and does not involve downtime of the unit.

"There are no large moving masses, no noise, less heat. We expect the system to provide about 5 per cent more usable power output than the rotary convertors."

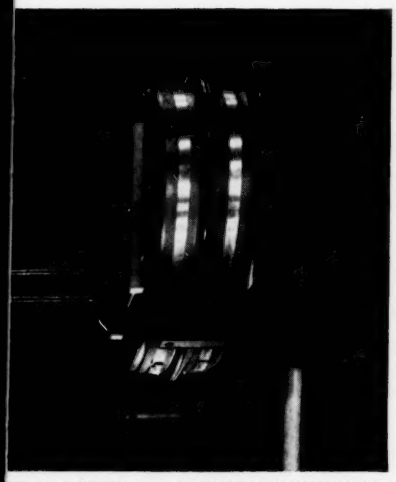
ABLE SYSTEM CIRCUIT PROTECTION and meter- s furnished by G-E metal-clad switchgear. Vertical lesign provides greater safety, easier maintenance.



ADJUSTABLE, AUTOMATIC DC CURRENT control of the load by a G-E Pyranol† Inductrol voltage regulator helps assure more accurately-controlled power.

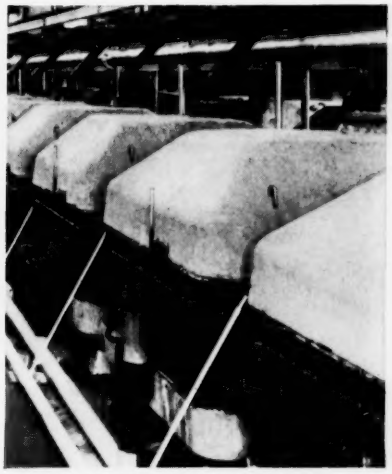


SIMPLICITY of G-E air-cooled silicon rectifier design permits tray removal in seconds, requires no system downtime.



IERAL ELECTRIC DC CURRENT TRANSFORMERS uce system installation cost, increase safety. The ent transformers are used in metering circuits.

REMOTE CONTROL of four circuits is permitted with G-E main control panel. Separate control panels for each circuit help assure more efficient use of power.



SILICON RECTIFIER SYSTEM OPER-ATES Hooker Type S-3A cells, similar to these, for chlorine-caustic soda process

Power Rectifier System

om AC to DC, the silicon rectifier power system was signed with General Electric equipment to help assure e most economic use of electric power. Adjustable, tomatic DC current control of the load to within 1% is accomplished by a General Electric Inductrol* ltage regulator. The cleanliness, simplicity and ease of aintenance of the air-cooled silicon rectifier units help oid costly downtime. The entire system is tied together th easy-to-install General Electric LVD busway and mor-clad cable.

nit responsibility is the key to maximum coordina- on of the system equipment in the Hooker installation. ecause Hooker selected one supplier, General Electric uld offer its engineering know-how and system- gineered equipment in a combined effort. The result for Hooker was a more simplified, efficient and economical electrical system.

For more information on General Electric's system-engineered equipment and technical assistance, contact your nearest General Electric Apparatus Sales Office. Meanwhile write for bulletin GEA-6684A, "Semiconductor Rectifier Power Conversion Systems," from the General Electric Company, Section 686-2, Schenectady 5, New York.

**Registered trademark of General Electric for induction regulators.*
†Registered trademark of General Electric for Askarel.

Engineered Electrical Systems for the Electrochemical Industry

GENERAL ELECTRIC

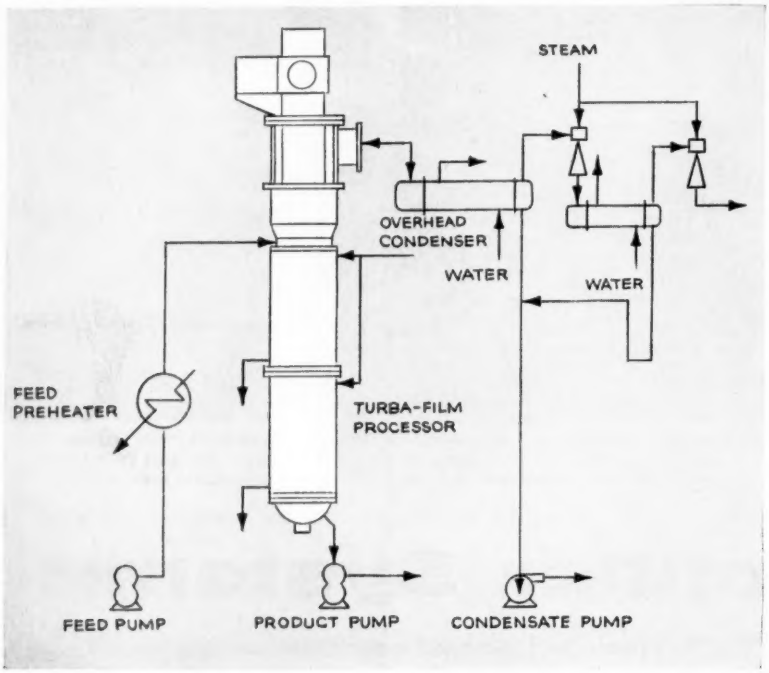
RODNEY HUNT

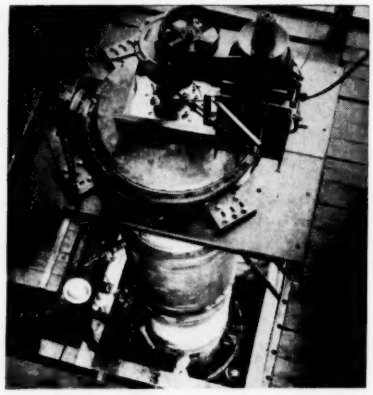
FLUID PROCESSING

RODNEY HUNT MACHINE CO., Process Equipment Division, 31 VALE STREET, ORANGE, MASS.

RODNEY HUNT PROCESSORS PROVIDE A SIMPLIFIED SOLUTION TO COMPLEX PROCESSING PROBLEMS

Rodney Hunt Turba-Film and Vacu-Film Processors have proven to be extremely versatile not only in the range of industries and products they serve, but also in the different kinds of processes they perform. These units assure closely controlled uniformity of product in processes such as – distillation . . . steam distillation . . . concentration . . . deaeration . . . deodorization . . . liquisolids . . . desolventization . . . and homogenization. The flow chart below illustrates a typical DISTILLATION process – one of the widest applications for the Turba-Film Processor. In this flow sheet, caprolactum is distilled from a residue consisting of dimers and trimers. Short time of contact and positive flow make the Turba-Film unit ideal for heat-sensitive and time-sensitive materials. Multi-stage units can also be used depending on the requirements of the process.

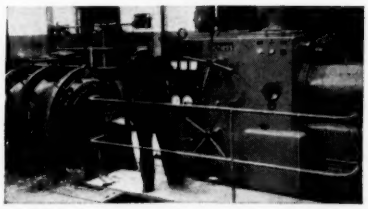




LARGEST TURBA-FILM PROCESSORS IN PRODUCTION AT RODNEY HUNT

Three large Turba-Film Processors have been ordered to increase production in the concentration of urea solutions. Each Processor has three inside thermal sections, 42″ in diameter and 72″ long. From the top of the integrally-mounted drive to the bottom of the unit, including thermal sections and separator, each Processor will measure 31′. The photograph above shows one of the Processors being readied for inspection and test runs in the test stand at Rodney Hunt.

The picture on the right shows the Turba-Film Processor's 27 ft. stainless steel rotor being acid cleaned in preparation for final finishing.



The photograph above shows special machine tools required for boring the inner shells of the Turba-Film Processor. Because of precision requirements, close tolerances must be maintained between this wall and the blades of the rotor.

FILL IN COUPON FOR MORE INFORMATION ABOUT RODNEY HUNT PROCESSING EQUIPMENT

Please send me the bulletins checked.

- ☐ THE TURBA-FILM PROCESSOR
- ☐ THE VACU-FILM PROCESSOR
- ☐ THE LABORATORY VACU-FILM PROCESSOR

Name.....

Title.....

Company.....

Address.....

Mail to: Rodney Hunt Machine Co., Process Equipment Division, 31 Vale Street, Orange, Mass.

DEVELOPMENTS . . .

NOVEMBER 2, 1959

Chementator

T. PETER FORBATH

Latest firm hit by government's cancellation of boron fuel production: Stauffer. Company has quit making boron trichloride at Niagara Falls plant, may switch to other metal chloride manufacture there.

Westinghouse claims it can build nuclear reactors producing power at 7.3 mills/kw., says it's ready to take orders for three ranging in cost from $28.3 to $72.4 million.

Becco Chemical has come up with what's called the first practical continuous epoxidation process. Company says process is ready for pilot planting, is offering it to the trade for further development.

One in, one out of dimethyl sulfoxide

Early in 1960 Crown Zellerbach will start up a 5-million-lb./yr. dimethyl sulfoxide plant in Bogalusa, La. And, partly to feed the DMSO plant, company is building a 10-million-lb./yr. facility nearby for kraft-lignin-derived dimethyl sulfide.

Addition of CZ to list of DMSO producers is balanced by a loss—which leaves a total of one in the business. Stepan Chemical had been producing the chemical for several years, had climbed over the 1-million-lb./yr.-output mark when a plant explosion last June suspended operation. Decision to rebuild hasn't been made.

First volume use for DMSO turned up last spring: spinning solvent for a new acrylic fiber of Toyo Rayon in Japan. Reportedly, several other Japanese firms are waiting in the wings to put it to similar use (*Chementator*, Apr. 20, p. 73).

About half the current DMSO market is in Japan. Other applications include use as solvent in agricultural chemical manufacture, as ingredient in industrial cleaners and for cleaning foundry molds.

CZ describes its DMSO process as a liquid phase oxidation of dimethyl sulfide using air or oxygen in the presence of oxides of nitrogen as catalysts. Process, to which CZ has exclusive U.S. and Canadian rights, is owned by Swedish firm Hagglund & Enkvist who also developed the process by which CZ recovers dimethyl sulfide from spent kraft liquor.

Solids or liquids: Rocketeers' dilemma

Virtually sure that Russia's lead into space is a matter of fuel superiority, rather than hardware, U. S. rocket researchers are bending the largest share of their talents to this area. But plaguing their efforts is the controversy over what makes the best propellant system—solid materials or liquids, or something else entirely.

Case for liquids got a strong boost last

New

The latest refinement in a long-tested, proved and improved explosion-proof combination Motor Starter & Circuit Breaker, this new Crouse-Hinds Condulet® EPC-M59 brings you tomorrow's convenience, dependability and safety at yesterday's prices.

Designed to conform with the National Electrical Code requirements for Class I, Groups C and D; Class II, Groups E, F and G; and Class III, it provides for built-in breathers and drains . . . built-in push-button stations, selector switch and pilot lights . . . seven taper-tapped conduit entrances . . . starter below breaker for safe, easy maintenance . . . compact design to permit a greater number of controls in any given area.

Now available in 7" and 9" sizes for Sizes 1 and 2 starter combinations. For more detailed information consult your Crouse-Hinds distributor, or any of the offices listed below.

ALL THESE NEW FEATURES

1 NEW raintight joints for both top and bottom covers

2 NEW shoes and guidance slot for easier interior assembly mounting

3 NEW built-in pilot lights available where visual indication desired

4 NEW easier-to-lock breaker handle (takes up to 3 padlocks)

5 NEW center section (and covers) of lightweight aluminum

6 NEW notched covers loosen quickly with pinchbar or screwdriver

7 NEW larger internal space for wiring ease

8 NEW replaceable 3-hole bracket makes mounting quick, easy

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MAIN OFFICE AND FACTORY: SYRACUSE, NEW YORK
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• TRAFFIC CONTROL SYSTEMS • AIRPORT LIGHTING and WEATHER MEASURING EQUIPMENT

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month when Southwest Research Institute demonstrated the feasibility of encapsulating liquid fuel or oxidizer in metal shell. Technique involves dipping dry-ice-frozen plastic capsule containing liquid into molten aluminum or magnesium, so obtains continuous metal film over plastic without melting it or destroying liquid within. Eventually SwRI hopes to eliminate plastic part of the pill.

Should technique be perfected, handling of liquid propellants—now a tricky affair and the source of strongest arguments against liquids—could be made as easy as that of solids. Small metal-encased liquid droplets, alternately of fuel and oxidizer, would behave as a fluidized solid, could be compacted as a solid mass in a rocket engine. Metal shell would insure that reactive materials remained separated until firing, then would enter propellant system to provide extra punch.

But solids, too, are strengthening their position. Case in point: Thiokol has developed a completely continuous and automatic solid propellant process—from compounding to final motor assembly—which is now in the final pilot-plant stage at Army's Longhorn Ordnance Works in Marshall, Tex. Large-scale plant is planned for the site in the space made available by recent $6.5-million expansion of facility.

Chief virtue of continuous processing is that it lends itself to elegant instrumentation and close process and quality control. This means more uniform grain compounding and curing, thus more reliably performing rockets.

Besides straight solids or liquids systems, more exotic techniques are making their bids as propellants. Of them, nuclear energy now has a chance to gain a foothold. National Aeronautics and Space Administration has begun negotiations with Lockheed for a $1-million, 3-yr. contract to provide engineering data for a nuclear rocket using liquid hydrogen as fuel.

Add a craft to ease multi-craft problem

One way out of the plant engineer's problem of having to deal with many, narrowly limited maintenance crafts may rest, paradoxically, in the creation of still another craft.

Dow's assistant maintenance manager at Freeport, Tex., P. J. Gurklis, proposes the establishment of an across-the-skills plant mechanic. Not intended by any means to replace skilled journeymen, the plant mechanic would be semi-skilled in a number of maintenance crafts such as that of millwright, machinist, boilermaker and pipefitter, would be able to handle simpler jobs involving them.

Need for such a man stems from the fact that under current union-craft practice plant engineer must call in a legion of skilled journeymen to perform even the simplest of repairs. For example, it often takes a millwright, electrician, pipefitter and instrument man to replace a pump. This results in excessive downtime, means detailed planning to work in all crafts which could lay jurisdictional claim to work, so avoid union wrangle.

A single plant mechanic could handle all aspects of a simple job, leave journeyman free for more complex work.

Chemical process industry management has long sought to change present craft set up, claims it's virtually impossible to administer. Bulk of CPI labor disputes in recent years have snarled specifically over this problem. Union leadership, on the other hand, is understandably concerned about protecting jobs of its membership, resists any attempt at craft-setup modification whose intent might smack of job elimination. Plant mechanic scheme may be a solution to satisfy both parties.

New cat cracking process makes debut

Backed by nearly 100,000 pilot-plant hours and one year of commercial operation, California Research now puts a new catalytic hydrocracking process up for licensing. Termed Isocracking, process converts marginal stocks into unusually high octane gasoline —and does it at mild temperatures, over 100% volume yields and competitive costs.

Key to these features is an unidentified "rugged new catalyst" for which Cal Research is now seeking patents. According to company, it permits cracking and associated reactions to take place around 500-700 F. rather than above 900 F. as is usual in conventional cat cracking.

Low temperature operation means that refractory distillates like heavy cracked naphtha, light cycle oil and coker distillates can be economically upgraded into gasoline blend stock with, after moderate reforming, 103-105 octane ratings. And it means that little fuel gas, coke or other low-grade products are produced when usual cat cracker feeds are used.

Cal Research maintains that new process can be carried out in conventional cracking

(Continued on p. 22)

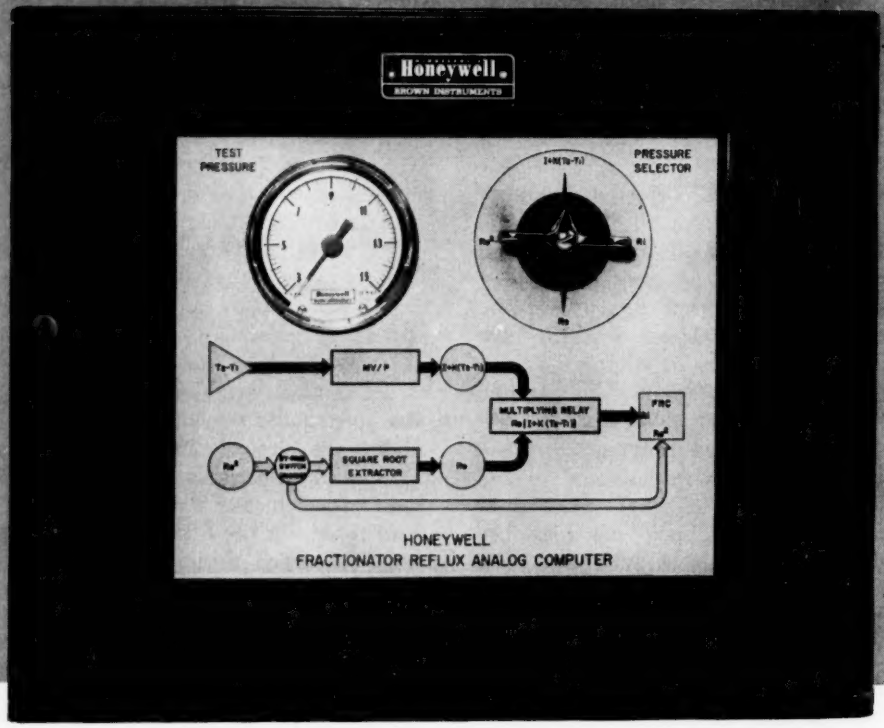
$Ri = Re\,(1 + K\,(T_2 - T_1))$

Ri—Internal reflux

Re—External reflux

$K = \frac{\text{Specific heat of Re}}{\text{Heat of Vaporization of Liquid on top tray}}$

$T_2 - T_1$—Temperature difference between external reflux steam and overhead vapor



Honeywell "Frac" unit is easy to use and maintain

- **Standard Honeywell components**
- **Standard Honeywell strip chart case**
- **Simple, easily accessible connections**
- **Chassis pulls out for front-of-case servicing**

COMPONENTS

MV/P Transmitter (millivolt-to-pressure)

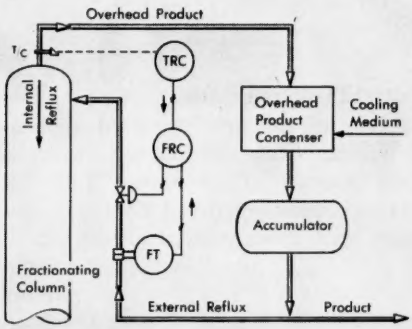
- Fully transistorized
- Continuously sensitive to temperature change
- Constant voltage supply
- Simple span and zero adjustments

Pressure selector and test pressure gage

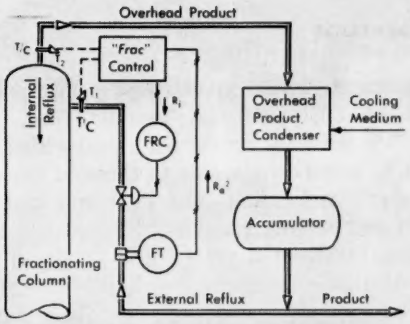
- Provide check of all pneumatic pressures within the computer for simplified trouble shooting.

By-pass switch

- Permits switching from internal to external reflux flow measurement and control.



PROBLEM *with existing system of controlling Fractionator*—Column is upset when (1) temperature of overhead product is indirectly affected by varying atmospheric conditions, and (2) temperature of cooling medium to overhead product condenser varies.



SOLUTION—*"FRAC"* Controller System*—The "FRAC" Controller measures differences in temperature of overhead product and external reflux flow of Fractionator Column. It computes, records and maintains best "Internal Reflux Flow Rates" by adjusting external reflux flow rate to get most efficient Fractionator Column operation.

New Honeywell "FRAC"* Controller stabilizes fractionating column operation

- **Easily Installed and Maintained by Present Instrument Technicians**
- **Savings Realized Justifies Installation**
- **Tamper-proof Design**

This new Honeywell control system immediately adjusts column operation to the effects of ambient temperature on overhead product condenser and external reflux. It continuously computes *internal* reflux flow, to maintain the most efficient, economical fractionating tower operation.

The new method, originally developed and licensed by Phillips Petroleum Company, utilizes a simple Honeywell analog computer employing standard industrial electric and pneumatic instrument components.

In correcting instantly for temperature deviation, the new control system offers many economies. Less reboiler heat is required, because large surges of internal reflux that would lower temperature are eliminated. Reduction in off-specification product minimizes re-runs and the need for intermediate storage. Quicker on-stream time allows fuller use of equipment. Closer control permits fractionator to operate closer to the flooding point. Elimination of condenser temperature controls reduces both equipment costs and maintenance.

Get complete details from your nearby Honeywell field engineer. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

*Fractionator Reflux Analog Computer. Trademark, Minneapolis-Honeywell Reg. Co.

Honeywell

H HONEYWELL *First in Control*

equipment. Initial investment in Isocracker is put at $350-$450/bbl. reactor feed. With 50-70% per-pass conversion, Isocracking operates at costs comparable to those of two-stage catalytic reforming. Cal Research estimates that Isocracking plant would pay out, before taxes, inside of 2 yr.

Initially company developed new process as a means of upgrading West Coast's perennial excess of marginal middle distillate stocks and fuel oil. But company claims Isocracking has versatility to take on refinery jobs throughout U.S. Among them: octane improvement generally, gasoline volatility control, increasing cracking capacity and gasoline production.

Cal Research's parent, Standard Oil of Calif., is running first commercial Isocracker at its Richmond refinery to upgrade marginal stocks and fuel oil.

Nuclear heat returning to fashion?

Belief in nuclear process heat, subject to the same sort of fickleness as feminine fashions, seems likely to be coming into style once more.

• Vitro Corp. has developed a package nuclear reactor that it claims can produce process steam competitively with fossil-fuel plants. Still working out design details, company plans to market unit before spring of 1961. Prime target: medium-size chemical firms.

• Atomic Energy Commission has issued bid invitations for design and construction of $4-million, 40-megawatt (thermal) pressurized-water Experimental Low-Temperature Process Heat Reactor (ELPHR). Unit will provide 125,000-lb./hr. steam to Interior Dept.'s 1-million-gal./day sea-water conversion plant to be on stream in California (likely at Point Loma near San Diego) in 1962.

AEC predicts that know-how gathered with ELPHR will make nuclear heat competitive with coal in high-cost-fuel areas by 1970. A New England coal-fired plant of same size would cost around $1.5-million and produce steam for 90.5¢/1,000 lb. ELPHR is presently expected to do job for 99¢/1,000 lb. but AEC feels operating experience will show the way to dropping figure to 87.6¢/lb.

Potential users of process heat reactors still have serious reservations, chiefly about financing. Because of technical and economic uncertainties, they feel that AEC should pick up the initial investment bill. It was on this point that one of the first proposed applications of nuclear heat—Michigan Chemical's $2.5-million reactor (*Chementator*, July 14, 1958, p. 71)—bogged down and a wave of disillusionment with nuclear heat set in.

AEC is studying possible financing techniques ranging from outright Commission ownership to industry-AEC shared construction costs. One booster of nuclear heat, a reactor manufacturer, suggests a joint industry-government steam station located in the center of a chemical complex.

Paint news: Water-soluble, fast-dry

Archer-Daniels-Midland plays opposing roles in a pair of newsmaking paint developments this month.

• Company has unveiled a strikingly fast-dry alkyd resin for auto and industrial finishes. Claims ADM, its Aroplaz 6006 used in solvent-based paints hardens to a tough enamel coat in 5 min.—and does it without oven drying. Melamine-alkyd resins take about 30 min., require heating at 250-300 F.

• Company has taken on some competition in the still lonely but widely attractive field of water-solution finishes. American Cyanamid has put on the market a water-soluble melamine acrylic resin, Melaqua 600, for industrial and automotive finishes. Late last year ADM led the way into this virgin territory with its Arolon 1000.

Five-minute dry of Aroplaz is tied to its fast-oxidizing properties. Enamels must not only throw off solvent but oxidize for proper hardening. Usually time-consuming baking is required to speed oxidation. In way of explaining fast-oxidizing properties of Aroplaz, ADM, seeking patents, says only that new resin is a "structurally balanced molecule."

Comparable in drying time to lacquers, Aroplaz uses less expensive solvent, boasts higher solids-viscosity ratio. Lacquers use esters and ketones as solvents, contain 27% solids. Aroplaz uses xylol and contains 50% solids. High solids content means that one coat of new enamel will do where two of lacquer would be needed. Speed and economy of application are expected to offset Aroplaz's 27-28¢/lb. tag. Older resins cost about 22¢/lb.

Cyanamid's Melaqua 600 is aimed at same markets as Aroplaz and Arolon with the addition of original automotive equipment. Automotively speaking, Aroplaz limits its ambi-

NEW from BAKER & ADAMSON®

SbF_3	Antimony Trifluoride, Purified	
	Chloral Hydrate, U. S. P.	$CCl_3CH(OH)_2$
CrO_2Cl_2	Chromyl Chloride, Tech.	
	Cobalt Chloride, Anhy. Powd. Reagent	$CoCl_2$
$CoCr_2O_7 \cdot 1\frac{1}{2}H_2O$	Cobalt Dichromate, Tech.	
	Ferric Pyrophosphate, Soluble, N. F. VII	
	Iso Amyl Alcohol, Reagent Grade	$(CH_3)_2CHCH_2CH_2OH$
$MgCrO_4 \cdot 5H_2O$	Magnesium Chromate, Tech.	

11 FINE CHEMICALS

new products . . . new grades, strengths, forms for you to investigate and work with

	Manganous Nitrate, 58% Solution, Electronic Grade	$Mn(NO_3)_2$
K_2SO_4	Potassium Sulfate, N. F. VII, Crystal & Powder	
	Silicon Tetrafluoride, Purified	SiF_4

Here are some of our newest fine chemicals—one or more of which may fill a need or provide a lead for you. Two of these products—silicon tetrafluoride and chromyl chloride – have not previously been readily available. Others are new in grade, or strength, or physical form. All are additions to the B&A line of more than 1000 reagents and fine chemicals which are recognized as offering the highest in chemical quality and purity.

Development of these products is typical of B&A's responsiveness to industry needs. As America's leading producer of reagents and fine chemicals, Baker & Adamson continues to set the pace in chemical purity with new products . . . new levels of purity for established products . . . new forms, new grades, new strengths.

If you would like information about any of the 11 fine chemicals listed above, or about B&A's many other high purity chemicals, please call or write your nearest Baker & Adamson sales office.

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Fine Chemicals

Allied Chemical

GENERAL CHEMICAL DIVISION
40 Rector Street, New York 6, N. Y.

tions to refinishing, Arolon to interiors. Melaqua will cost 65¢/lb., Arolon 45¢/lb.

Contractor quits equipment manufacture

Another engineering-contracting firm has quit the heat exchanger manufacturing business. M. W. Kellogg tells *CE* that it plans to shut down its Jersey City shop within the next 6 months. Some 35 engineers at the facility have already located new jobs.

Along with heat exchangers, Kellogg will discontinue its line of pressure vessels and rocket casings but will stay in power piping.

Kellogg's decision follows similar ones made by at least three other engineer-contractors. Lummus sold its exchanger business, Badger dropped its exchanger line and Foster Wheeler stopped soliciting heat exchanger jobs—all within the last two years.

Kellogg points out that stiffening freight rates make it uneconomical to fabricate equipment at a point far removed from point of use. Contractors do better limiting themselves to design of equipment, then subcontracting manufacture to vendor located in reasonable shipping distance from construction site.

Too, company points out, export market is pretty well shot. Resurgent European manufacturing with lower operating expenses can outbid U. S. firms on overseas projects. And growing trend to standardization of once tailor-made equipment has also hurt firms.

Tomorrow's Technology

Today's embryonic developments which have special significance for chemical engineers

Boost and setback for beryllium

In Dynamic Metals' announcement that it has found the means of making flotation separation of beryl ore possible (*Chementator*, Oct. 5, p. 35), the beryllium industry got one of its firmest technical boosts. This month the industry is getting some more of the same —but this time with a setback mixed in.

At its Salt Lake City lab, Bureau of Mines has discovered a combination of materials that may show still another way to a beryl ore flotation process. Report BuMines researchers, by preparing ore surface with hydrofluoric acid or petroleum sulfonate, or sodium chloride with sulfuric acid, beryl ore can be made to float free of host material with such fatty acids as linoleic or oleic.

Importance to beryllium industry of this work stems from the fact that currently all beryl must be hand picked from host rock in a process called cobbing. A commercial flotation process would cut price of beryl ore (now $340-$530/ton) by eliminating this costly procedure, so open new markets to the metal.

Too, a commercial flotation process would unlock low-grade U. S. beryl reserves to insure adequate domestic supply. This would remove the scarcity stigma now attached to beryllium and inhibiting applications research.

On the applications front, however, a shadow was cast over beryllium's future. M. C. Adams of Avco-Everett Research Lab (Everett, Mass.) predicted at the High-Temperature Symposium at Asilomar, Calif., that advances made in ablating techniques would soon outmode heat-sink approach to rocket re-entry problem. Use of vaporizing (ablating) ceramics and plastics for the job of keeping space vehicles from burning up on re-entering earth's atmosphere would replace need for heat-absorbing beryllium.

Fuel cell nearer commercialization

Allis-Chalmers, which but a year ago held that its fuel cell was only a lab device (*Chementator*, Nov. 3, 1958, p. 49), has brought its work in the field to the threshold of commercialization. But to do it, the company has quietly switched from a hydrogen-oxygen system to propane and air.

Last month A-C showed off a compact fuel-cell power package driving a full-size tractor at various speeds, forward or reverse. And a company spokesman indicated to *CE* that a number of A-C product departments were urging the Research Div. to turn the development over to them for grooming for commercial production.

Demonstration power package, mounted neatly on the 5,720-lb. tractor along with its propane fuel supply, consists of 1,008 1-v. cells each measuring ¼-in. thick by 12 in. square. Cells are arranged in 4 banks with 112 units of 9 cells per bank. Package delivers 15,000 w. to a standard A-C 20-hp. d.c. motor. Tractor exerted over 3,000 lb. of drawbar pull on a multiple-bottom plow.

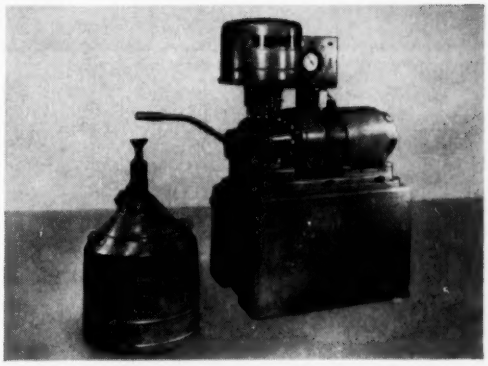
For more on DEVELOPMENTS.....26

NORELCO and CRYOGENICS

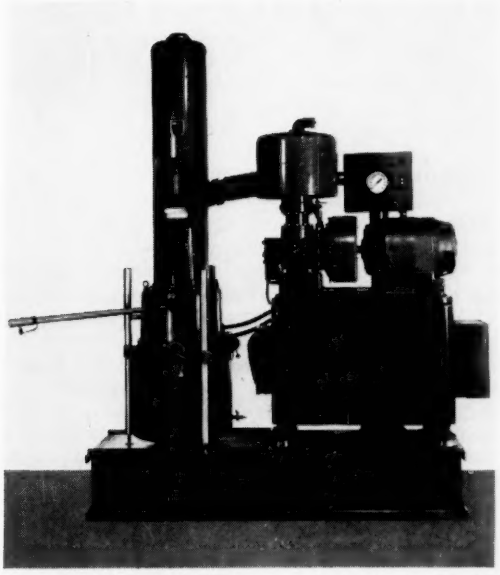
GAS PURIFICATION
GAS SEPARATION
AIR SEPARATION
CONVERSION OF GASEOUS O_2 and N_2 TO LIQUID PRODUCT
METAL TREATMENT
COLD CHAMBERS
LIQUID AIR PRODUCTION
LIQUID NITROGEN PRODUCTION
PRESERVATION OF BIOLOGICALS
COLD MACHINING
LOW TEMPERATURE PULVERIZATION
SHRINK FITTING

All of the applications listed–and more–stem from the one unit–THE NORELCO CRYOGENERATOR. Available in four different capacities, this remarkable unit consists of a single-stage refrigeration machine designed for operation in the range of minus 320 degrees F. to ambient temperatures.
As a basic cryogenic tool, the cryogenerator is completely adaptable to a tremendous number of applications and is in fact being widely used by a host of manufacturers and laboratories throughout the country.
Since the operating principle is identical for all models, specific applications of each depend primarily on the capacity of the system rather than the form of equipment. The four models, designated A, B, C and D, have respective refrigeration capacities of 3,000, 12,000, 40,000 and 160,000 BTU/hr. at minus 320 degrees Fahrenheit.
"Packaged" units consisting of a Model Cryogenerator with special headers or accessory equipment are also available.

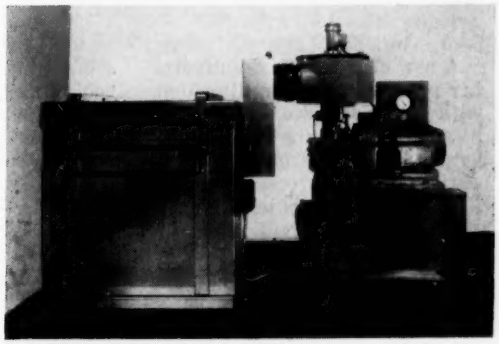
Research facilities at the Norelco Cryogenics Application Laboratory are available for consultation on industrial problems involving any low temperature application. Write today for illustrated brochures and complete technical information.



AIR LIQUEFIER – This unit liquefies air at atmospheric pressure – thereby insuring a contaminant-free product. Rate of production is 7½ liters per hour.



NITROGEN GENERATOR – Comprised of a Model A Cryogenerator acting as a nitrogen condenser and an atmospheric pressure separation column. Rate of production is 6 liters per hour over an uninterrupted period up to 200 hours.



ENVIRONMENTAL CHAMBER – A specially insulated storage chest is used in conjunction with a Model A Cryogenerator. This permits the production and maintenance of temperatures down to minus 320 degrees F. for environmental testing.

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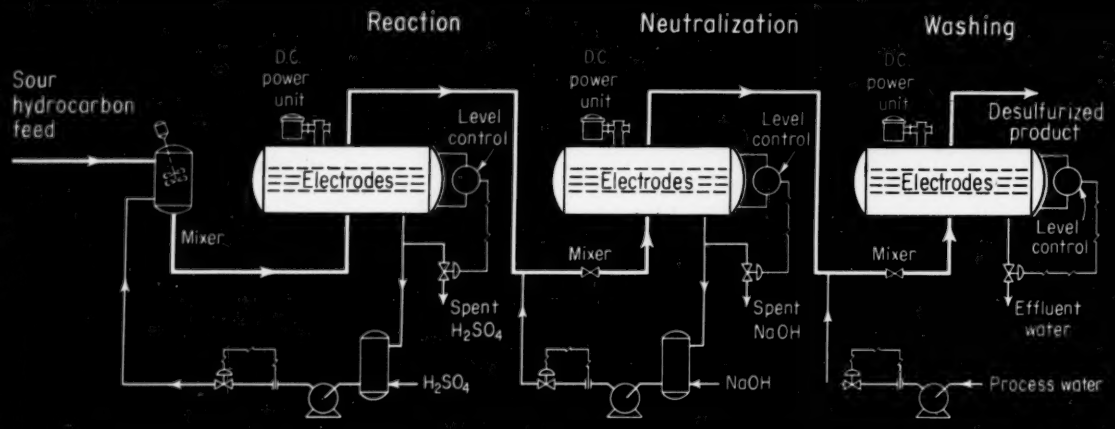


New Desulfurizing Process Takes Hold

After some rough moments in early shakedown, new electrostatic desulfurizing process begins to show promise as a valuable tool for petroleum refiners.

A new electrostatic desulfurizing process, used in conjunction with sulfuric acid contacting, is now busily seeking jobs in the petroleum and petrochemical industries. The process, termed Electrostatic Desulfurization by developer Howe-Baker Engineers, Inc., Tyler, Tex., uses a new chemical engineering tool—electrostatic mixing—to remove sulfur efficiently, is particularly applicable to reformer feedstocks.

With a hard-won commercial success to its record, the process is slated for two more refinery jobs. An 8,000-bbl./day unit has been at work for over a year treating reformer feedstock at Cities Service's East Chicago, Ind., refinery. After some operating troubles, the unit is now "doing all that's claimed for it," says Cities Service.

A second, 2,000-bbl./day unit has been built for Commonwealth Oil & Refining at Ponci, Puerto Rico, to treat cracked visbreaker naphtha. And on stream this month is a 1,150-bbl./day unit for reformer feedstock at Imperial Chemical Industries' Billingham, England, refinery.

▶ **High Sulfur Removal**—Howe-Baker reports that sulfur removal can be as high as 95%. In a typical operation that reduces sulfur from 300 ppm. to 22 ppm., arsenic, too, is reduced from 5-17 ppb. down to 0-4 ppb.

Cost of a 10,000-bbl./day unit shouldn't be more than $350,000. Total operating costs vary from 7.9¢/bbl. using fresh acid down to 4.8¢/bbl. if spent alkylation acid is used.

Treating losses are less than 0.5% with straight-run naphthas, but increase with larger amounts of unsaturates and higher molecular weights in feedstock.

▶ **A New Tool**—A key to highly efficient sulfur removal, says Howe-Baker, is a new chemical engineering tool called electrostatic mixing. But some skeptical oil men question this term and wonder just what, if anything, is new (see box, top of page 27).

Electrostatic mixing, according to Howe-Baker, uses electrical energy to accelerate conductive particles or ions in a

Typical Electrostatic Operating Data

Naphtha charge, bbl./day	8,000
Temperature, deg. F	80
Reaction stage:	
Acid circulation rate, lb./bbl	12.5
Acid mixer speed, rpm	120
Electrode power consumption, kw	1
Temperature, deg. F	82
Insoluble acid carryover, % by vol	0.002
Neutralization stage:	
Caustic circulation rate, bbl./day	400
Caustic mixing valve pressure drop, psi	8
Electrode power consumption, kw	1
Temperature, deg. F	85
Suspended caustic carryover, % by vol	Nil to trace
Water wash:	
Water injection rate, bbl./day	400
Water mixing valve pressure drop, psi	4
Electrode power consumption, kw	1
Temperature, deg. F	81
Suspended caustic carryover, % by vol	Nil
Estimated yield loss, % by vol	0.4

What Engineers Say About Electrostatic Processing, Pro & Con

R. J. PHILLIPS,
*Howe-Baker Engineers, Inc.**

With proper particle size and distribution, the high-voltage field used in electrical coalescers will agitate dispersed particles and insure better contact with the continuous phase. But electrical coalescing alone would not achieve desulfurization efficiencies in the 90-95% range. Laboratory studies showed that proper electrode geometry employing a high-voltage, low-current-density field would provide a mild electrolysis which would increase sulfur removal efficiencies to the desired range.

L. C. WATERMAN,
*Petreco Div., Petrolite Corp.**

We have observed the agitation of emulsion particles under the influence of an electric field. We regard this movement as being only one of the steps in electrical coalescence. From a mixture of light naphtha and sulfuric acid flowing into an electric precipitator, more than 90% of the acid falls out as bulk sludge, never influenced by the electric field. Power consumed by the electrode system of an Electrofiner precipitating acid sludge from 8,000 bbl./day of reformer stock is about 100 watts, hardly enough to supply energy for mechanical or electrolytic purposes.

*From a paper and comments at API refining meeting in New York, May 28, 1959.

nonconductive medium. Electrical energy transmitted to the system imparts violent and rapid motion to dispersed particles.

Howe-Baker distinguishes between electrostatic mixing and electrostatic precipitation in this way:

When voltage gradient is relatively low, polar or charged particles tending to align along lines of electrostatic force are, nevertheless, subject to local hydraulic eddy currents and are whirled about. Mixing is further promoted by resulting changes in local dielectric constant. Particles of acid or emulsion are whipped rapidly through the hydrocarbon phase.

In electrostatic precipitation, a much stronger field, about 10 times that for mixing, restrains conductive particles pretty much along the lines of electrostatic force, in spite of eddy currents. Particle mobility, except along the lines of force, is practically nil until particles get so big that they settle out.

▶ **Three-Stage Route**—Here's a run-down on process operation.

Naphtha feed enters a small vessel equipped with turbine-blade mixers, where sulfuric acid (88-98%) is added and the solution is mixed, reducing acid particle size to an optimum diameter.

Hydrocarbon containing the acid dispersion enters the bottom of the acid stage. Here, electrostatic mixing insures maximum oxidation of sulfur compounds to disulfides. These are preferentially soluble in the acid phase which is continuously drawn off. Electrical field in the upper part of this reaction vessel effects virtually complete separation of hydrocarbon and sulfuric acid.

In the second stage, weak caustic neutralizes sulfuric acid carryover, as well as small amounts of acidic reaction products and naturally occurring organic acids. Entrained acids are neutralized in the bottom of this stage, while caustic droplets coalesce in the upper part. A water-wash stage insures final cleanup, and naphtha then goes to an activated alumina dryer.

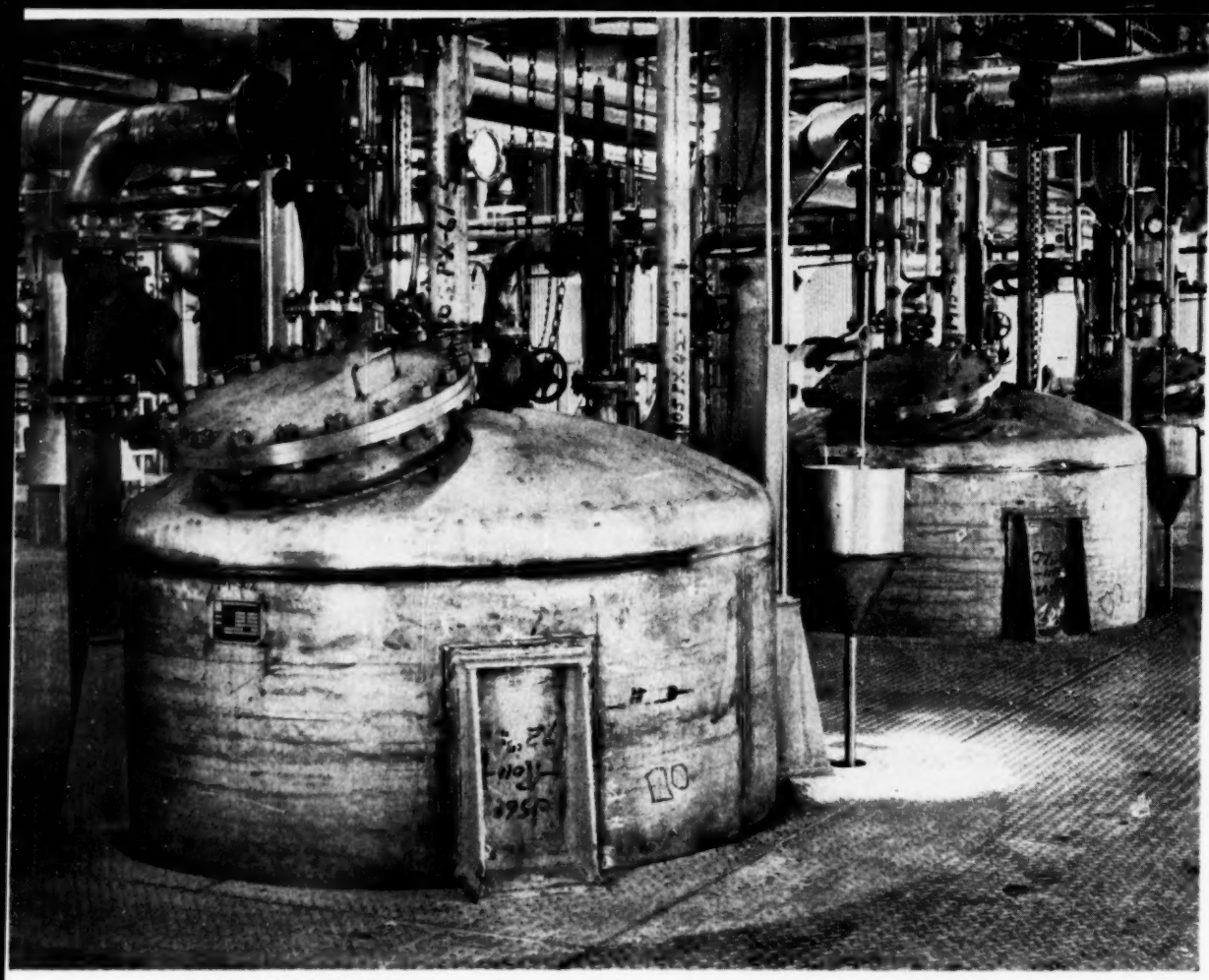
▶ **Some Rough Spots** — Ken Youngblut of Cities Service's East Chicago refinery, tells of some rough spots in early process shakedowns.

Cities Service ran into some messy corrosion problems and was using more caustic than it should. Reason for the latter, Youngblut believes, was presence of complex organic acids in the acid-stage effluent. Corrosion was chiefly in the acid-contacting stage, though some occurred later after incomplete neutralization.

Cities Service and Howe-Baker have largely licked these problems by changing from recirculating caustic to a once-through system, and by pumping a purge oil (dried naphtha product) through electrical insulator housings to prevent accumulation of conductive treating agents. Purge oil joins the main stream of naphtha being processed. Cities Service also added a glass-wool coalescer after the acid stage to prevent carryover.

▶ **Proved by Test**—Howe-Baker has made a number of tests on treated naphtha for sulfur, arsenic, chloride, lead and other contaminants. Results show that the process is now meeting all performance guarantees, removing over 90% of sulfur. Discoloration tests carried out to check for traces of high-boiling constituents have showed that naphtha contains less than that treated by hydrogen processes.

Processes & Technology
Continued on next page.



PUMPER-DECANTERS give new solvent extraction system an edge over its predecessors.

Carrier Change Boosts Extraction Rate

- Leads to more effective extraction equipment set up.
- Increases solvent concentration to raise throughput.
- Handles richer feed slurry, reduces acid requirement.

Development of a different solvent carrier and equipment are the keynotes of a higher throughput, low-cost extraction process operated by Mallinckrodt Chemical Works at the AEC's Weldon Spring, Mo., nuclear-reactor feed-materials plant.

Together, these associated improvements return a clear $1 million/yr. saving in operating cost over the operating bill for the AEC's obsolete ether-extraction plant which shut down after the June 1957 startup of the present unit.

▶ **Uses Hexane Carrier**—Basically, this gain stems from choice of *n*-hexane as the carrier for tributyl phosphate (TBP) solvent used to extract uranium from uranyl nitrate solution produced in digesting ore concentrates.

By virtue of its low 0.69 specific gravity and viscosity, the *n*-hexane can carry TBP (sp. gr. 0.98) in concentrations up to 50% and still maintain efficient mass transfer and separation of phases. Thus, process achieves higher throughput rates than previous process from comparable equipment.

A measure of this increase is provided by information released on pilot runs. Using clear solution feed containing 200 g./l. uranium, rather than the slurry

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Remember, today's trend is toward low cost simplicity. LimiTorque operators with integral controls are designed with this in mind.

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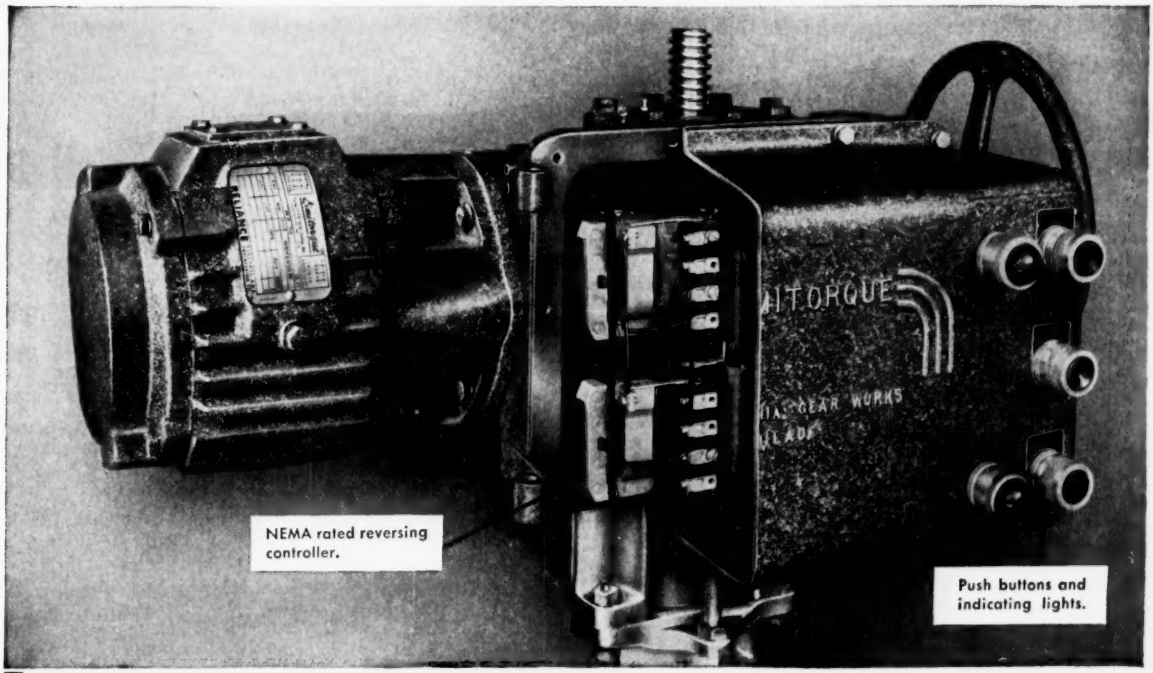

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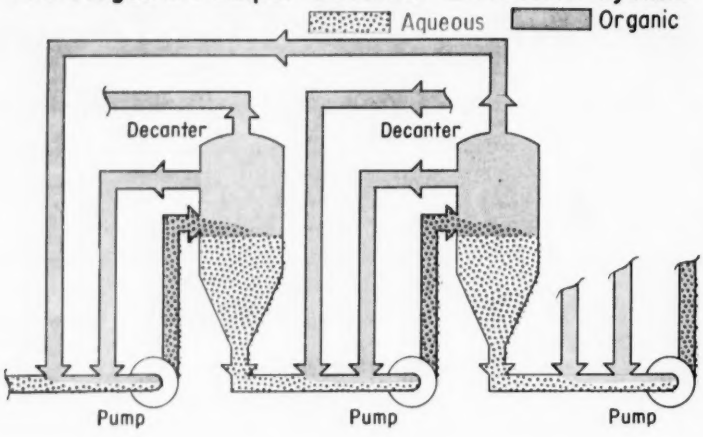
Two Stages in Pumper-Decanter Extraction System



handled in full-scale plant, the pilot unit increased throughput 37% to 96 gal./hr./sq. ft.

▶**Needed, New Extractor**—In conventional extraction equipment, this solvent system and the aqueous slurry tended to form stable emulsions when agitated enough to permit good phase contact. To overcome this tendency, Weldon Spring engineers developed extraction equipment which would minimize emulsification by providing high solvent to aqueous ratios at points of agitation. Called a pumper decanter, this extractor is a type of mixer-settler with external mixing in a centrifugal pump.

Aside from eliminating the emulsification problem, pumper-decanters can handle high-solids slurries. Mallinckrodt capitalizes on this unique capability by feeding thicker slurries, richer in uranium, to the circuit in order to increase extraction efficiency.

Higher uranium concentration increases the nitric acid recycle within the multiple-stage extraction system. In turn, this permits reduction of acid concentration in the aqueous feed, eliminating need for recovering acid from the raffinate. From these characteristics comes the process name: high-uranium, low-acid process.

▶**Feed for Extraction**—Weldon Spring process starts with uranium ore concentrates (40-75% U) from Grand Junction sampling and assaying facilities.

Concentrate is crushed, screened, sampled, milled and classified. Then nitric acid (45% concentration) digests the concentrate in four parallel-arranged 5,000-gal. digesters, equipped with agitators and steam coils to heat the liquor to 210 F. Digestion is rapid.

▶**On to Extraction**—Uranyl nitrate slurry from digesters flows to four, 6,000-gal. stainless-steel cooling vessels where the temperature is dropped to 100 F. Cooled slurry flows to the extraction circuit, consisting of five stages operating countercurrently. Each stage consists of a centrifugal pump mixer and a 2,500-gal. cylindrical stainless-steel decanter vessel.

For each stage, organic-aqueous mixture discharging from pump flows tangentially into cylindrical body of decanter. Phases disengage by centrifugal and gravity forces. An interface is automatically maintained.

Aqueous phase flows downward and out to the mixing pump of the downstream stage. Organic phase travels upward and over to the mix-pump of the upstream-stage decanter.

Organic phase also recycles to the pump of the same stage for mixing with the underflow from the upstream stage. A high organic to aqueous flow ratio in this pump discourages the formation of stable emulsions, despite the vigorous mixing.

Solvent losses in the final-stage raffinate run as low as 0.01%. Lean, fresh solvent enters the extraction circuit at the final-stage, mixing pump intake.

▶**Wash and Strip**—Uranium-rich solvent from the top of the first extraction decanter flows to a 30-ft.-tall, 2-ft.-dia. stainless-steel pulse column, equipped with perforated plates. Here, impurities, picked up during extraction, are washed from the solvent. Because of *n*-hexane's low specific gravity, column has larger plate perforations than for kerosene carrier, upping throughput 300%.

Impurity-free pregnant solvent flows to a pair of identical columns, feeding in at the bottom. Water flowing downward through the upward pulsing solvent strips uranyl nitrate out of the solvent stream.

▶**Purify and Denitrate**—Uranyl nitrate solution then passes through several purification steps. First, in a column, hexane strips entrained TBP from the solution. Then a small, steam-heated evaporator drives off dissolved hexane.

Hot stream flows to a triple-effect evaporator, where the solution is concentrated to 7 lb./gal. uranium. Further evaporation converts the uranyl nitrate to a hydrate, between tri- and tetrahydrate.

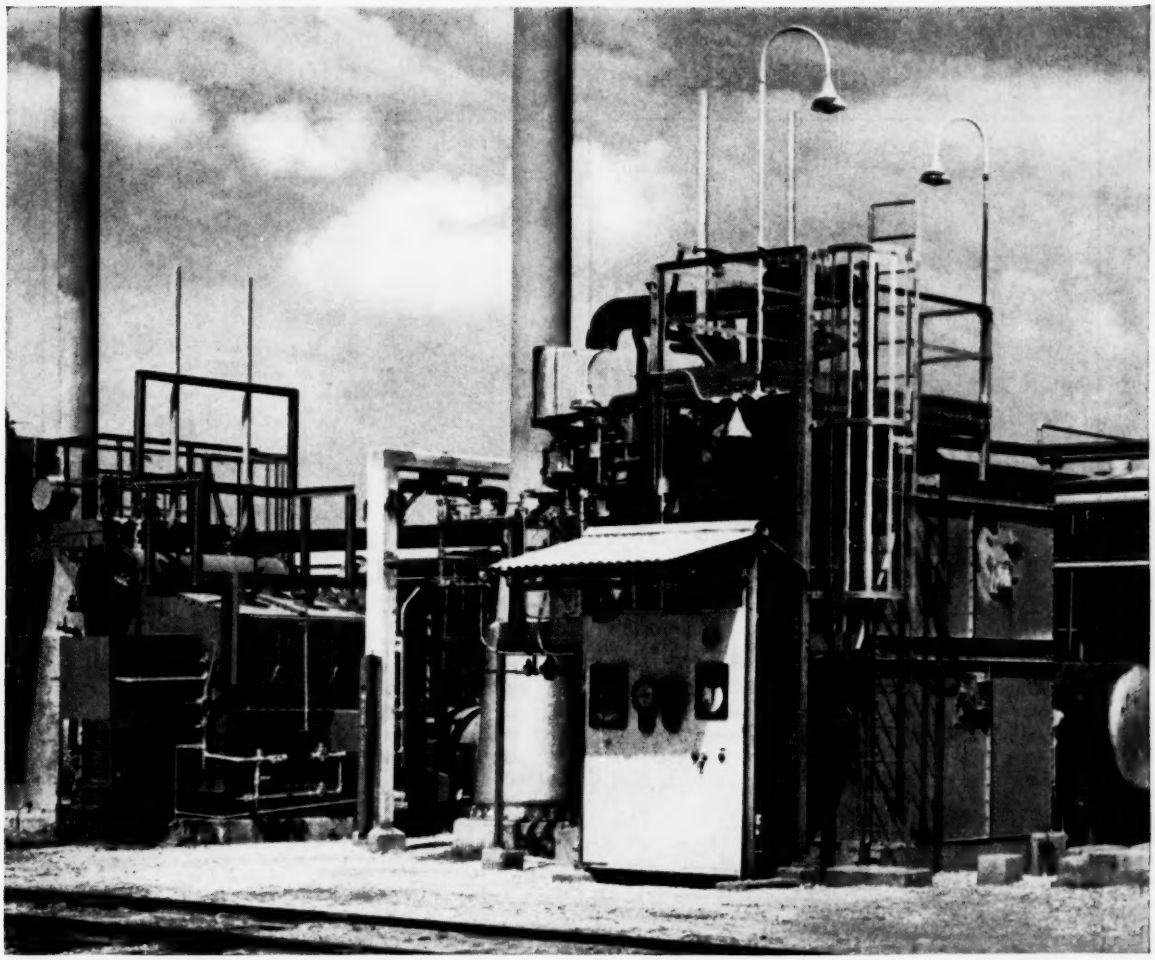
High purity hydrate flows to denitrators, 50-gal. stainless-steel vessels equipped with propane burners. Resulting orange oxide, uranium trioxide, is discharged into 100-cu.-ft. hoppers.

▶**Final Steps**—Process steps that follow are similar to those employed at other AEC plants. Orange oxide is reduced in a fluid bed to uranium dioxide. Then HF hydrofluorinates the UO_2 to green salt, uranium tetrafluoride.

Last step is a reduction of green salt to uranium metal by magnesium. Some green salt is shipped to other AEC sites for conversion to uranium-hexafluoride feed for gaseous diffusion operations.

In uranium metal production, direct extrusion and casting of dingots into product uranium slugs, now gives higher quality at a lower cost.

Processes & Technology
Continued on page 32



The open secret that makes leading processors choose Foster Wheeler vaporizers again and again

When this picture was made, the Foster Wheeler vaporizer on the left had been in service for over three years, supplying 2,300,000 Btu per hour for processing of ethylene oxide and ethylene glycol, using Dowtherm as the heat transfer medium. When plant expansion became necessary, the processor again chose a Foster Wheeler vaporizer, the 3,700,000 Btu unit at right.

Such repeat installations have become virtually standard procedure for many of the process industry's blue-ribbon companies. One, for example, has placed 68 units in service over the course of 26 years.

This customer confidence is based on an "open secret". To make sure that the vaporizers are being applied to the best possible advantage, Foster Wheeler engineers review the engineering details of the entire process heating system. They use this information to tailor the vaporizer to the system. And in doing this, they are often able to make suggestions that result in savings for the processor, or a more efficient process.

Get full technical information on Foster Wheeler vaporizers and the *Heat Engineering* service that goes with them, by writing to Foster Wheeler Corporation, Dept. D, 666 Fifth Avenue, New York 19, N.Y.

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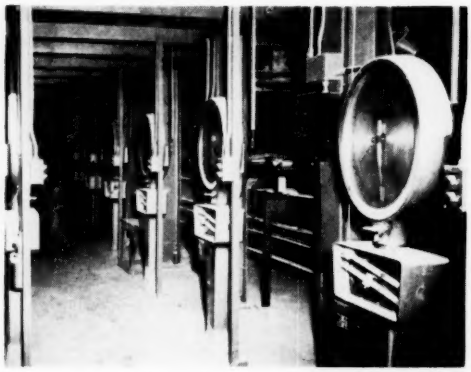

At New Refractories Plant, One Man Controls Sixty Batches

One man controls batching operations for brick making at H. K. Porter Co.'s new $12-million seawater magnesia and basic refractories plant at Pascagoula, Miss. With proper amounts of periclase and chrome ore set on digital indicators on panel at far left, operator pushes a button to feed dry materials into weigh hoppers. Panel controls feed to produce correct weights, then scans and checks weighing system to insure correct mix. At right is a partial view of the 60 batching bins and scales. Automatically weighed materials are released to conveyor belts and sent to proper mixers.

Symposium to Attack Computer Control Problem

Process engineers will learn more about application of control computers to their processes in a symposium planned for the 1960 Winter General Meeting of AIEE to be held in New York starting Jan. 31.

Papers are being solicited in the following areas: Definition and characterization of problems for control computers, new control computers, comparison of different computers or computer types for a single application, criteria for selecting computer types for control applications and techniques and concepts for the future.

In addition, a special problem has been posed to both processing and computer manufacturer technical men by Monsanto Chemical Co. The problem is an elaborate, quantitative description of a hypothetical chemical processing plant whose operation is to be optimized.

The Monsanto problem is the same one presented by T. J. Williams of Monsanto in the Schoch Lecture two weeks ago at the University of Texas.

Plant includes continuous stirred-tank reactor (subject to short-term feed fluctuations), decanting of crude product, distillation (capacity-limited by overhead condenser) for final pure product, and recycle.

Representatives of processing companies and computer makers recently met in Chicago to go over ground rules for attacking the Monsanto problem in terms of paper solutions of plant optimization for the Winter Meeting session. Consensus of CPI men there, was that the problem may well bring into the open some problems of computer application.

Prospective authors should contact the program chairman, G. L. Hollander, Philco Corp., Philadelphia 44, Pa. Final paper text must be submitted no later than Nov. 27.

Plant Boost Slated for Acids by Ozone Oxidation

Emery Industries is now expanding several-fold its production capacity for azelaic and pelargonic acids and derivatives at Cincinnati, Ohio. A total of $6 million will go into expansion of capacity for these acids, produced from oleic via ozone oxidation, and for such esterification products as plasticizers and diesters. The latter are finding fast-growing uses in the field of jet engine lubrication.

Process-wise, Emery isn't saying much about its ozonation route. It will use the same basic process as in the existing plant, with improvements that have been developed. Simply, ozone cleaves the doubled-bonded oleic acid at the C_9-C_{10} position, giving high yields of azelaic and pelargonic acids.

Processes & Technology Continues on page 34

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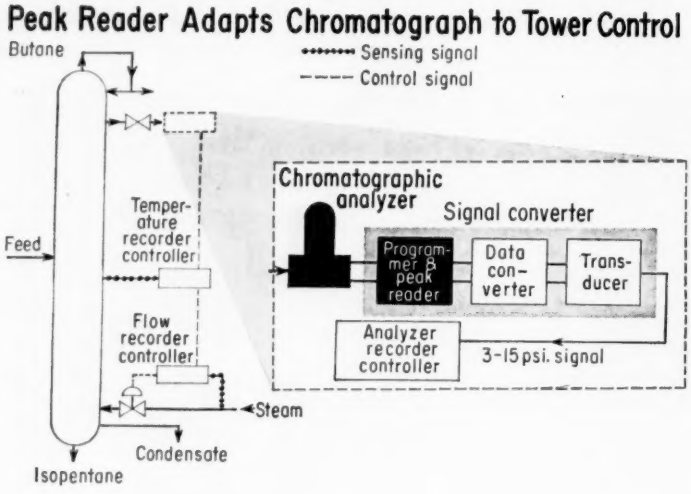


Cyclic Analysis No Bar to Control

Extended operation proves that periodic stream analysis can be modified to control continuously.

Phillips Petroleum Co., Sweeny, Tex., has proved unmistakably that its company designed peak reader device pays off impressively, adapting a chromatograph's periodic analyses to continuous process control.

During a year of operation hooked to the control system of a fractionator handling natural gas liquids, Phillips' combination chromatograph-peak reader has established that it:

- Increases recovery of important constituents (chiefly propane and isobutane) enough to return the cost of the chromatograph every two weeks.
- Improves product quality sufficiently to return the cost of the chromatograph every six weeks, independent of greater recovery.
- Reduces consumption of steam and cooling water so that this saving alone would have paid for the instrument in a year.
- Costs very little to operate. Chromatograph requires 30 w. of electricity, a tiny stream of helium and no maintenance. There has been only one minor repair on the analyzer; helium cylinder is replaced every three weeks.

▶ **Control Site**—Phillips' choice for a process unit to hook up with this control scheme is a 50-tray, 13-ft.-dia. debutanizing column operating on a feed mixture of propane, isobutane, normal butane, isopentane, normal pentane and natural gasoline. Column must operate so that all the butane goes overhead and all isopentane discharges with bottom product.

From ninth tray near the top of tower, chromatograph receives sample and analyzes it for propane, isobutane, normal butanes and isopentane. Controlling component is isopentane, which provides signal for corrective action in controlling steam flow to the reboiler through a temperature recorder-controller on the 14th tray.

▶ **Reads Peak**—When the chromatograph puts out a signal corresponding to the peak denoting the concentration of isopentane, it is "read" by a data converter called a peak reader. Output of the peak reader is a continuous signal which determines the set point for the temperature recorder-controller on the 14th tray.

At completion of each analysis every 5 min., peak reader signal will make a step change, corresponding to change in composition of the key component, isopentane. Through this step change the temperature recorder-controller gets a new set point to compensate for composition change and, thereby, alter column operation to maintain purity of overhead product.

▶ **Detailed Rundown**—Chromatograph puts out a millivolt signal that is amplified to 10-50-v. range by a d.c. amplifier. Amplification of this signal throws a relay which allows a capacitor to be charged to the maximum voltage of the amplified signal.

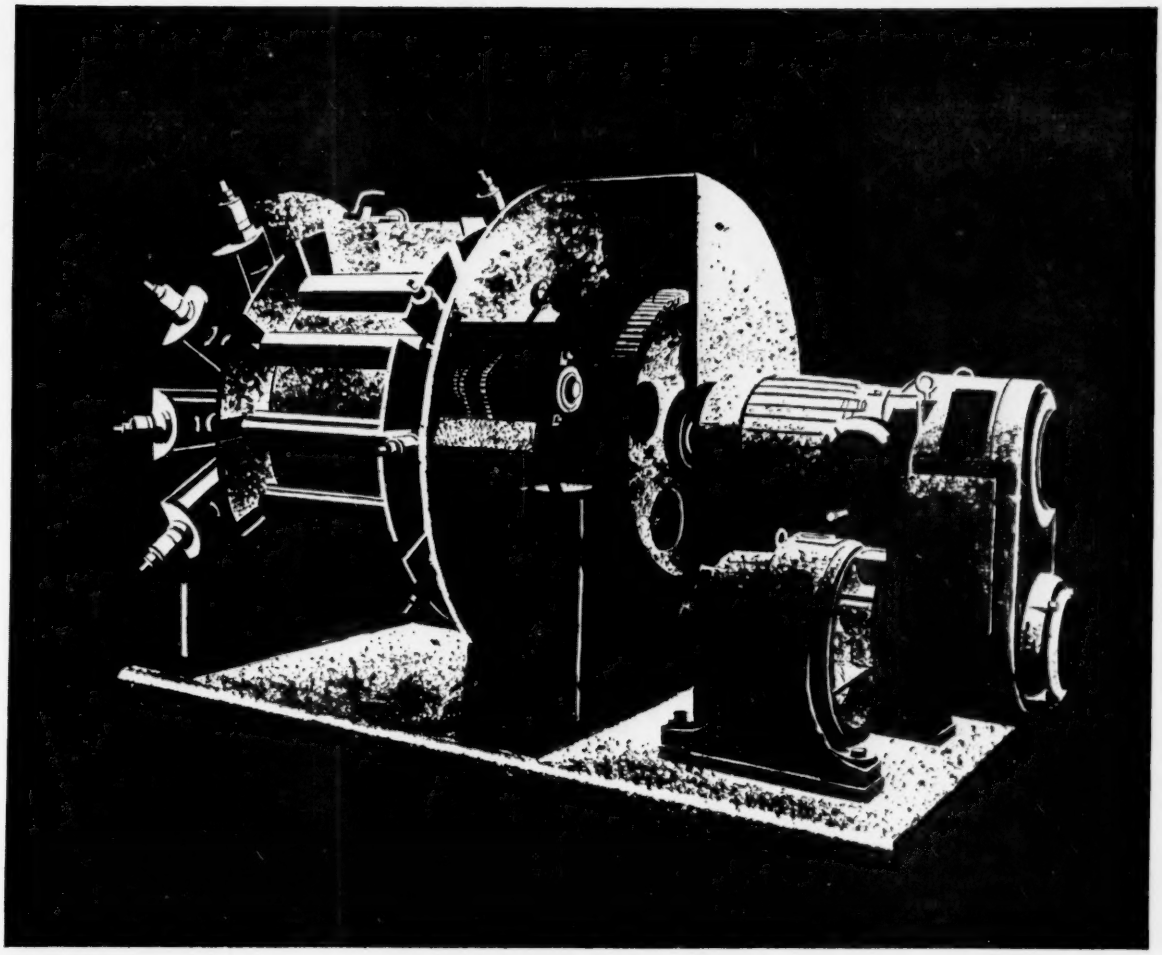
A servo amplifier compares this voltage with the output voltage of the data converter and, by driving a potentiometer, matches the latter with the new signal. This control output stays constant for the rest of the cycle.

Capacitor charge relay then de-energizes and the servo amplifier compares d.c. amplifier output with ground, repositions a potentiometer which corrects detector zero adjustment and also brings d.c. amplifier output to zero before the next cycle.

Russia Buys Complete U. S. Plastic Pipe Plant

What may mark the beginning of a trend in American-Soviet chemical process trade is the recent sale to the Soviet Union by Omni Products Corp. of a complete American-made plant for producing plastic pipe. Manufacturing Chemists' Assn. opposes export to Russia of technical know-how or equipment that would help the Soviets develop production of plastics raw materials. Omni points out, however, that its sale involves end-use production.

Omni says the plant is priced

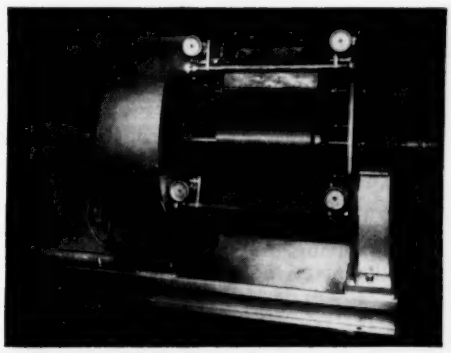


Still Another Example of Devine Manufacturing Skill

The machine you see above is a Drum Dryer, another fine processing tool from the J. P. Devine drawing board. This customer, as do many on the Devine list, had a special problem. Remember the dehydrated potatoes of World War II? Tasted pretty awful. The customer knew how this problem could be solved. The answer: This standard Devine Drum Dryer using a series of adjustable doctor rolls arranged to roll at the same peripheral speed as the heated drum, which gradually reduces the product to a thin even coating. A doctor knife on the opposite side of the drum flakes off the product, delivering a physically unchanged, easily packaged potato flake with a minimum rupturing of cells.

You may not need a Potato Flaker—or a Drum Dryer either, for that matter—but we think this example shows how J. P. Devine can help you solve your processing problems, enabling you to produce the best product in the most efficient manner.

Other Devine products for the Chemical Processing Industry:
Vacuum Dryers, Blenders and Mixers, Ball Mills, Autoclaves, Paint and Paste Mixers, Agitators, Impregnators, Kettles, Vacuum Pumps, Jacketed Valves, Pipes and Fittings, Code Design and Fabrication.



Rear View 24" Diameter by 18" Face
Potato Flaker, Showing Doctor Knife Assembly

J. P. DEVINE MFG. CO.
19th St. & A.V. R.R. PITTSBURGH, PA.

A UNIT OF COX INDUSTRIES

Write for our new catalog No. 201, with detailed descriptions of our complete line of Drying Equipment.

New York Office: 500 Fifth Ave., New York 36, N.Y. **Phone:** Wisconsin 7-7769 • **Export Office:** 50 Church St., New York 7, N.Y. **Cable Address:** "Brosites"

Twenty-Six Stages on the Road to Mandalay

No playground for flying fishes (or Zen Buddhists), Southern California Edison Co.'s Mandalay steam station near Oxnard, Calif., is the destination of this 26-stage flash evaporator shown just before shipment from Cleaver-Brooks Special Products plant at Waukesha, Wis. Mandalay station, scheduled for test runs this month, will be California's first general purpose seawater conversion plant, distilling 100,000 gal./day of fresh water from the sea. Evaporator is over 70 ft. long and weighs 40 tons, incorporating more than 8 mi. of aluminum-brass tubing, facts that would leave Kipling impressed, if not inspired.

at $1 million and can turn out 10,000 tons/yr. of plastic pipe, or about $10-$12 million worth annually. Plant will use Russian-made plastics, polyethylene and polyvinyl chloride, in manufacturing the pipe. Product of the plant, Soviets say, will be used for irrigation purposes.

Ground Is Broken for Engineering Center

Last month's ground-breaking ceremonies for the United Engineering Center, to be built opposite the United Nations in New York City, united old and new engineering generations. Earth-turning honors were shared by former President Herbert Hoover and Rensselaer Polytechnic freshman engineering student Jerry Fujimoto.

New structure is scheduled for completion in mid-1961 and will house headquarters of 18 major engineering societies with a combined membership of more than 300,000. Fund-raising campaigns for the center have so far netted nearly $8 million from industry and individual engineers.

Firms Groom Aluminum For Electromagnet Coils

Copper wire, traditionally used to wind electromagnetic coils may soon yield exclusive dominance of this major market to aluminum foil or sheet strip conductor.

Current activities by over a dozen coil manufacturers, an Alcoa spokesman revealed last month, presage sizable inroads of aluminum strip into the coil field. For over a year Alcoa has been making strip-wound coils in its research laboratories. Earlier programs by such companies as General Electric and American Machine & Foundry have been directed toward exploring new materials for transformers and reducing space and weight of coils.

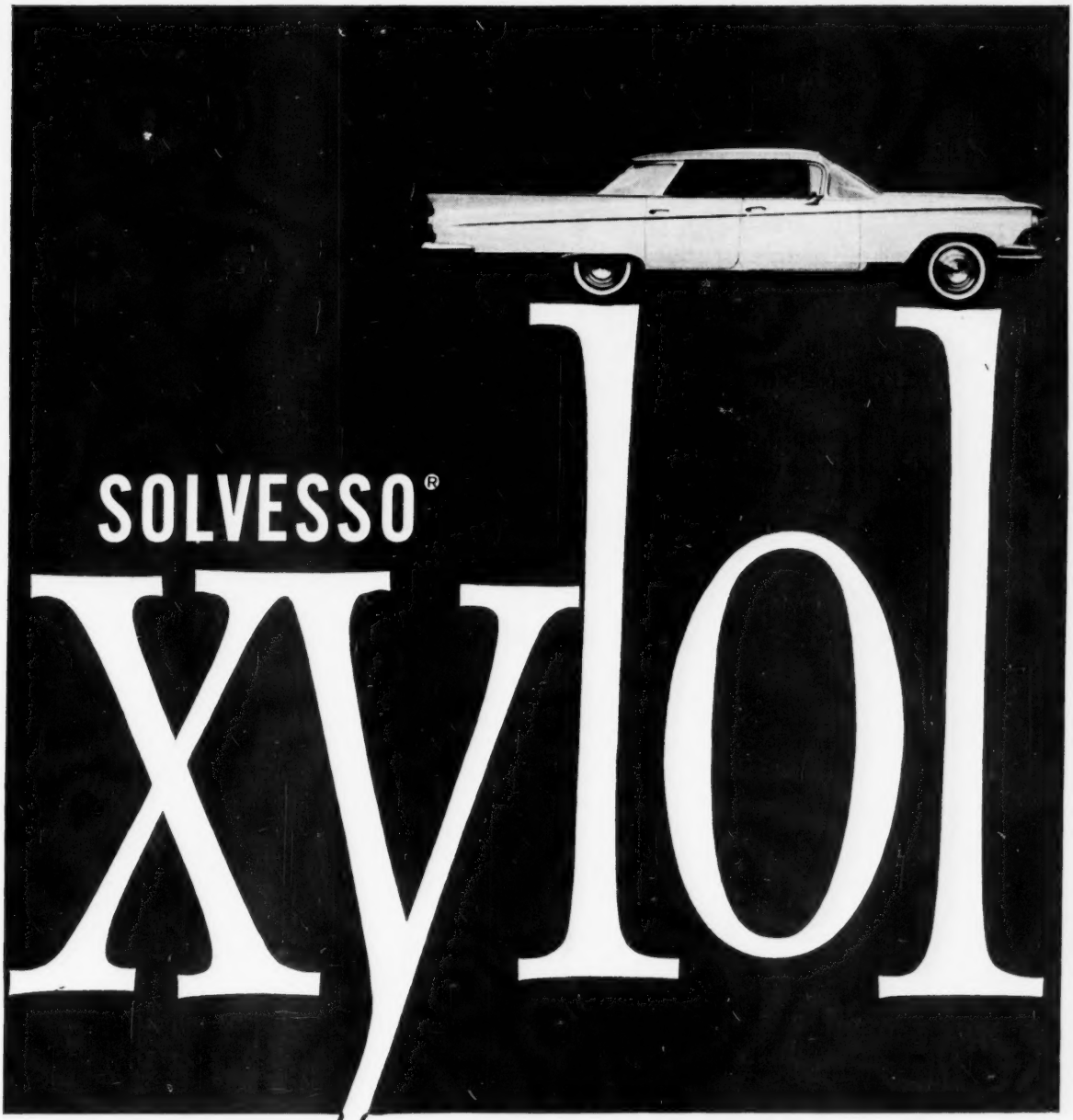
NEWS BRIEFS

Continuous furnace: Leningrad Mining Institute engineers have developed a new furnace for continuous production of nonferrous metals with a capacity 25-30% above that of conventional rotary types, claims Soviet news agency Tass. Ore is charged continuously at one end and, after slag is removed periodically, metal comes out at the other. A prototype has been operating at the Balkash copper combine in Kazakhstan.

Zirconium tubing: Harvey Aluminum, Torrance, Calif, is extruding zirconium alloy tubing in lengths up to 51½ ft. Previously tubing this length was made by welding together three shorter extrusions.

Isotope storage tank: "Research Institute for Hydrotechnique and Melioration," USSR, has designed a steel-and-concrete sub-soil storage tank for cobalt-60 and cesium-137. Lower part of this steel container is used for isotope storage; upper part contains 23½-in.-thick concrete for shielding.

Polycarbonate agreement: General Electric and Farbenfabriken Bayer have executed a cross-license agreement under U. S. patent rights of each of the two companies. Fields related to polycarbonate polymers are expected to be served faster as a result of the agreement, GE claims.



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The superior quality of Solvesso Xylol helps assure brilliance and durability in car finishes. Its purity and uniformity make it outstanding for many other types of surface coatings . . . particularly coatings for home appliances. And you can count on fast delivery and technical assistance for the most profitable application of Solvesso Xylol. Yesterday . . . today and tomorrow . . . Solvesso solvents are industry's first choice!

For further information or technical assistance, write: Esso Standard Oil Company, Solvents Division, 15 West 51st Street, New York 19, New York.

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PETROLEUM SOLVENTS

In Industry after Industry..."ESSO RESEARCH works wonders with oil"

DEVELOPMENTS . . .

CHEMICAL ECONOMICS

EDITED BY D. R. CANNON

- **90% of all people in chemical process industries (CPI) work in big plants (100-or-more employees)** . . . *see bottom, this page*
- **13% of all plants making chemically processed products are "outside" the CPI** . . . *next page*
- **More CPI people and plants are in stone, clay, glass and ceramics work than in any other field** . . . *page 42*
- **11% of all CPI plants are in the N.Y.-N.J. metropolitan area**

Here's Your CPI Census for 1959

The biggest privately sponsored nose-counting of American industry—McGraw-Hill's Census of Manufacturing Plants for 1959—is a matter of record now. (The last comparable job appeared in 1952.) And here are the highlights for the bustling sector of the U. S. economy that pays our board and keep, the Chemical Process Industries (CPI).

First of all, the 1959 Census shows the distribution of the chemical process industries.

- By plant size: 20-49, 50-99, and 100-or-more employees.
- By industry groups: 18 major divisions, more than 100 subdivisions.

Story continues on page 40

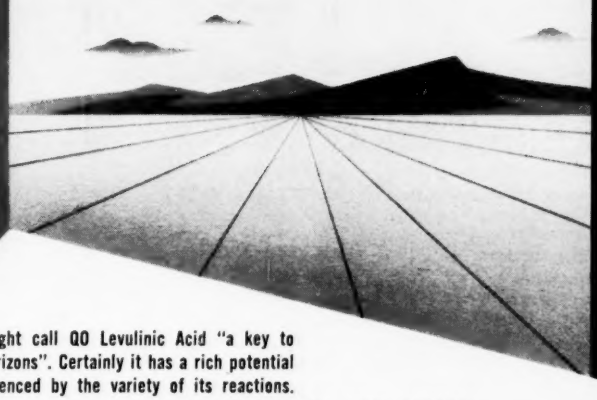
Summary of 1959 Census of Chemical Process Plants

Chemical Process Industry	Plants With 20-or-More Employees		Plants With 50-or-More Employees		Plants With 100-or-More Employees	
	Plants	Employees	Plants	Employees	Plants	Employees
Chemicals & Petrochemicals	1,202	273,616	742	259,749	487	240,408
Drugs & Medicines	565	122,213	366	116,264	227	107,512
Explosives & Fireworks	101	70,905	90	70,572	71	69,288
Fats & Oils	503	46,851	303	40,370	120	28,576
Fertilizers & Agricultural Chemicals	495	46,597	237	38,707	99	30,090
Foods & Beverages	1,436	235,841	925	220,194	548	195,313
Leather Tanning & Finishing	227	34,831	179	33,234	114	28,764
Lime & Cement	219	46,826	198	46,181	168	43,976
Man-Made Fibers	35	41,349	32	41,253	30	42,153
Metallurgical & Metal Products	870	164,997	485	153,570	274	139,938
Paints, Varnishes, Pigments & Allied Products	643	68,142	371	60,009	189	48,327
Petroleum Refining & Coal Products	668	313,506	489	308,103	365	300,268
Plastics Materials, Synthetic Resins & Nonvulcanizable Elastomers	215	71,335	162	69,670	102	65,824
Rubber Products	806	266,299	559	258,708	389	248,044
Soap, Glycerin, Cleaning, Polishing, Related Products	385	43,827	187	38,182	98	32,480
Stone, Clay, Glass & Ceramics	1,900	365,888	1,274	345,321	790	312,070
Wood, Pulp, Paper & Board	861	291,299	716	286,446	544	274,693
Other Chemically Processed Products	1,088	218,335	798	209,381	505	190,333
Industries With Secondary Products in the Chemical Process Industries	1,890	657,559	1,384	641,146	937	610,822
Total	**14,109**	**3,380,216**	**9,497**	**3,237,060**	**6,057**	**3,007,879**

Free—For your files—Check your Reader Service postcard (p.145) for an extra copy of this article.

BENEFITS OF QO CHEMICALS

QO® LEVULINIC ACID AS A NEW RAW MATERIAL



You might call QO Levulinic Acid "a key to new horizons". Certainly it has a rich potential as evidenced by the variety of its reactions.

Take a look at its formula . . . **$CH_3COCH_2CH_2COOH$**

IT'S POLYFUNCTIONAL. Levulinic acid can react as a carboxylic acid and as a ketone. The 1,4-spatial relationship of these functions frequently leads to cyclization to form heterocyclic types.

SOME TYPICAL REACTIONS. Reductive amination of levulinic acid offers a convenient route to 5-methyl-2-pyrrolidone or N-substituted homologs. Oxidation over a vanadium catalyst yields succinic acid. Dehydration gives 3-pentenoic gamma-lactone. Esterification goes forward normally using standard procedures. Condensation with phenol in the presence of strong acids gives 4,4-bis(hydroxyphenyl)pentanoic acid.

AVAILABILITY. QO levulinic acid is available from our pilot plant in cans and drums. Drum carload quantities can be supplied. The manufacturing process is suitable for full scale production on a commercial unit.

For further study of this polyfunctional compound, write for our new revised Bulletin 301-A.

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CHEMICALS DIVISION
335Y The Merchandise Mart, **Chicago 54, Illinois**
Room 535Y, 120 Wall Street, **New York 5, New York**
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• By geographical area: 48 states, plus the District of Columbia, and 66 major metropolitan areas ranging from New York to Flint, Mich.

▶ **New Feature** — And, as an added feature, a profile of non-CPI plants — plants not primarily concerned with chemical processing or manufacture but which do turn out CPI products as a sideline.

Taking the first standard of measure—plant size—and reading through the data, we note that nearly 90% of all CPI employees work in the biggest plants (100-or-more employees). And "big" plants make up barely 40% of total plants with 20-or-more workers.

In the field of man-made fibers, for example, 86% of all plants—and better than 99% of all employees—are in the big-plant category.

Of the 18 major chemical process industries, the stone, clay, glass and ceramics group employs more people and boasts more plants than any other group—16% of all plants and 13% of all employees, respectively.

▶ **New York Area Leads** — Of the 66 major metropolitan areas which are broken out of the statistics—only 53 were so handled in 1952—the New York City-Long Island-Northern New Jersey area ranks way out in front, accounting for fully 11% of all CPI plants and 12% of all CPI employees counted in the census.

The 66 areas covered, incidentally, account for 95% of all plants and employees in the CPI Census.

▶ **The "Outsiders"** — One new feature of this year's Census is a tally of the plants which are not, strictly speaking, CPI plants—those not primarily concerned with chemical processing or manufacture, but which do turn out at least one chemically processed material as a secondary product (see table, this page).

These non-CPI plants are by no means few in number. They add up to more than 13% of all plants making chemically processed products, and are a good indication of the strong competition for markets the CPI is running up against from "outsiders."

For full details of the 1959 CPI Census, write for Chemical Process Industries Report No. 120-10, c/o Chemical Engineering, Market Research Manager, 330 West 42nd St., New York 36, N. Y.

Some "Non Chemical" Plants Make Chemicals, Too

Manufacturing Industry*	Plants	Employees
Ordnance & Accessories	9	19,435
Food & Kindred Products	875	116,984
Tobacco Manufacture	1	170
Textile Mill Products	106	39,450
Apparel and Other Finished Products Made From Fabrics & Similar Materials	14	2,053
Lumber & Wood Products, Except Furniture	43	18,192
Furniture & Fixtures	21	3,888
Paper & Allied Products	87	43,007
Printing, Publishing & Allied Industries	12	6,305
Petroleum Refining & Related Industries	2	65
Rubber	35	5,630
Leather & Leather Products	20	5,519
Stone, Clay & Glass Products	38	8,803
Primary Metal Industries	45	16,047
Fabricated Metal Products, Except Ordnance, Machinery and Transportation Equipment	193	48,503
Machinery, Except Electrical	148	80,008
Electrical Machinery, Equipment & Supplies	86	44,553
Transportation Equipment	55	169,959
Professional, Scientific, Controlling Instruments; Photographic, Optical Goods; Watches & Clocks	38	14,316
Miscellaneous Manufacturing Industries	62	14,672
Total	1,890	657,559

* Plants listed under these categories are primarily concerned with nonchemical processing or manufacture, but do turn out at least one chemically processed material as a secondary product. Most plants in such broad classifications as "Petroleum Refining & Related Industries," and "Paper & Allied Products," turn out—as their primary product—a chemically processed material and thus have already been accounted for in tables on pp 38, and 42.

See CPI census breakdown by industries, pg. 42.

Who'll Use All That Sodium?

Sodium metal reached a production peak in 1956 and has been sliding downhill ever since: to 133,000 tons in 1957, 110,000 tons last year, barely 100,000 tons this year (based on four-month figures).

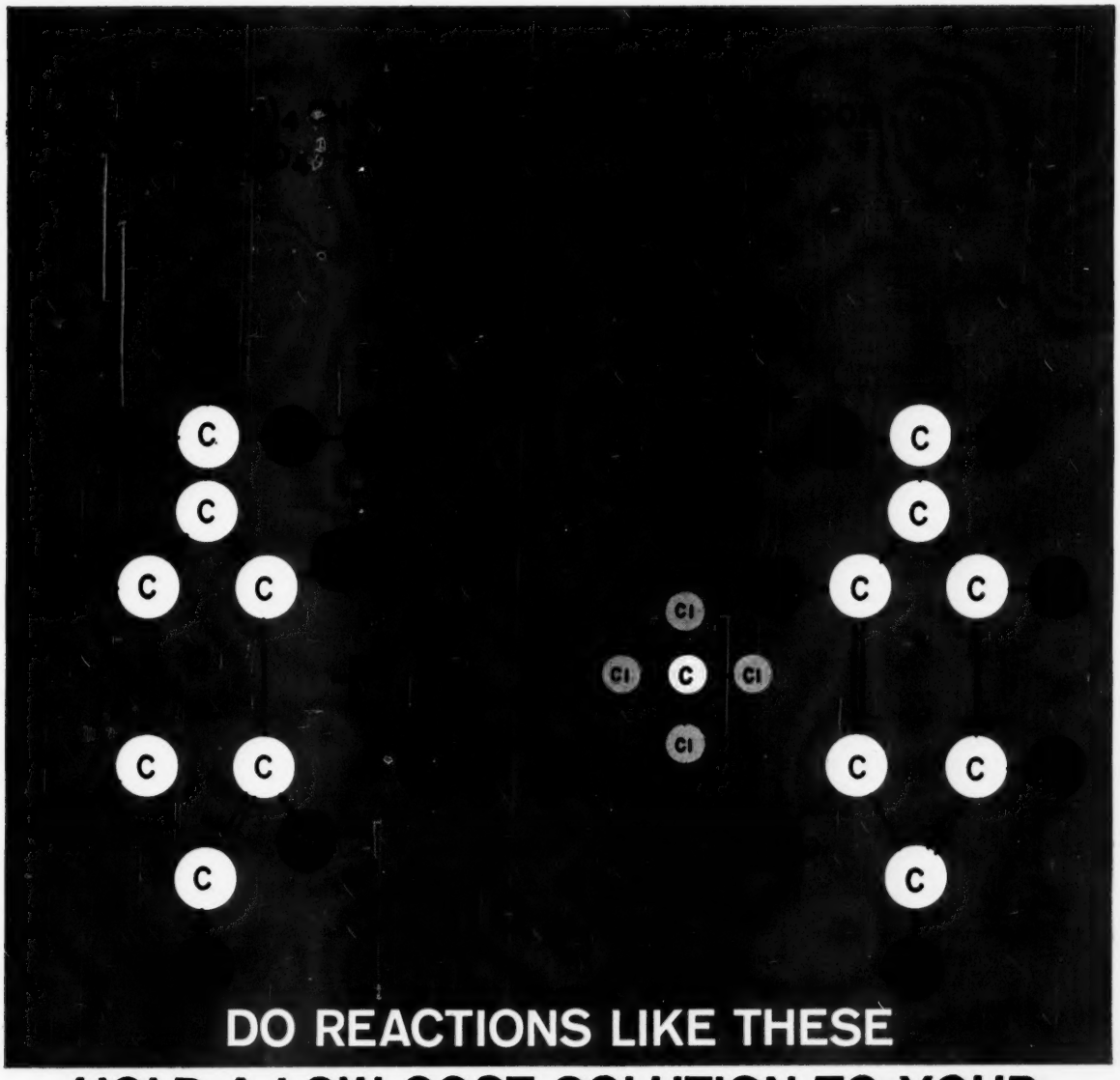
Yet capacity is still on the rise. Du Pont's new 45-million-lb./yr. plant at Memphis, Tenn., boosts national capacity to 180% of total 1958 production.

Says Stanford Research Institute's chemical economics newsletter, "Prospects of utilizing this excess capacity in the near future are not too bright."

Sodium's principal end use, tetraethyl lead—which accounts for about 75% of the metal produced—cannot do the job alone. Its growth potential is 5%/yr. at best, according to SRI.

Reduction of such new metals as zirconium and titanium—once such a promising outlet for sodium—is stalled, waiting for the day when these metals become competitive with other materials used by private industry.

Sodium consumption in detergent manufacture dropped to nil last year when Procter & Gamble completed conversion of its fatty alcohol facilities from sodium reduction to catalytic hydrogenation.



DO REACTIONS LIKE THESE

HOLD A LOW COST SOLUTION TO YOUR OXIDATION PROBLEMS?

Allied Nitrogen Tetroxide is a low-cost oxidant. It can be used in the wood pulping, rubber, metal recovery, and lubricant purification industries, and for many other applications. Perhaps this versatile chemical can solve some of *your* oxidation problems.

See the box at right for further reactions. For further information and application data on Allied Nitrogen Tetroxide, write for Allied's 59 page product bulletin "Nitrogen Tetroxide".

Allied Nitrogen Tetroxide is shipped in tank-cars, one-ton cylinders, or 125 and 150 pound cylinders.

NITROGEN TETROXIDE CAN BE USED AS A LOW COST OXIDIZER:

- ... At very low temperatures in the form of solutions, such as NO in N_2O_4
- ... In concentrated liquid form from −11° to 21°C
- ... In acids such as sulfuric and nitric
- ... As a gas in form of NO_2 at elevated temperatures
- ... As a solution in carbon tetrachloride or chloroform from 0° to 30°C for such oxidation reactions as
  - Aromatic alcohols to aromatic aldehydes;
  - Alkyl aryl carbinols to ketones;
  - Alcohol groups in starch or cellulose to carboxyl groups;
  - Thiols to sulfonic acid.

For specifications and local offices, see our insert in Chemical Materials Catalog, pages 435 - 442 and in Chemical Week Buyers Guide, pages 35 - 42.

BASIC TO AMERICA'S PROGRESS

2819

NITROGEN DIVISION

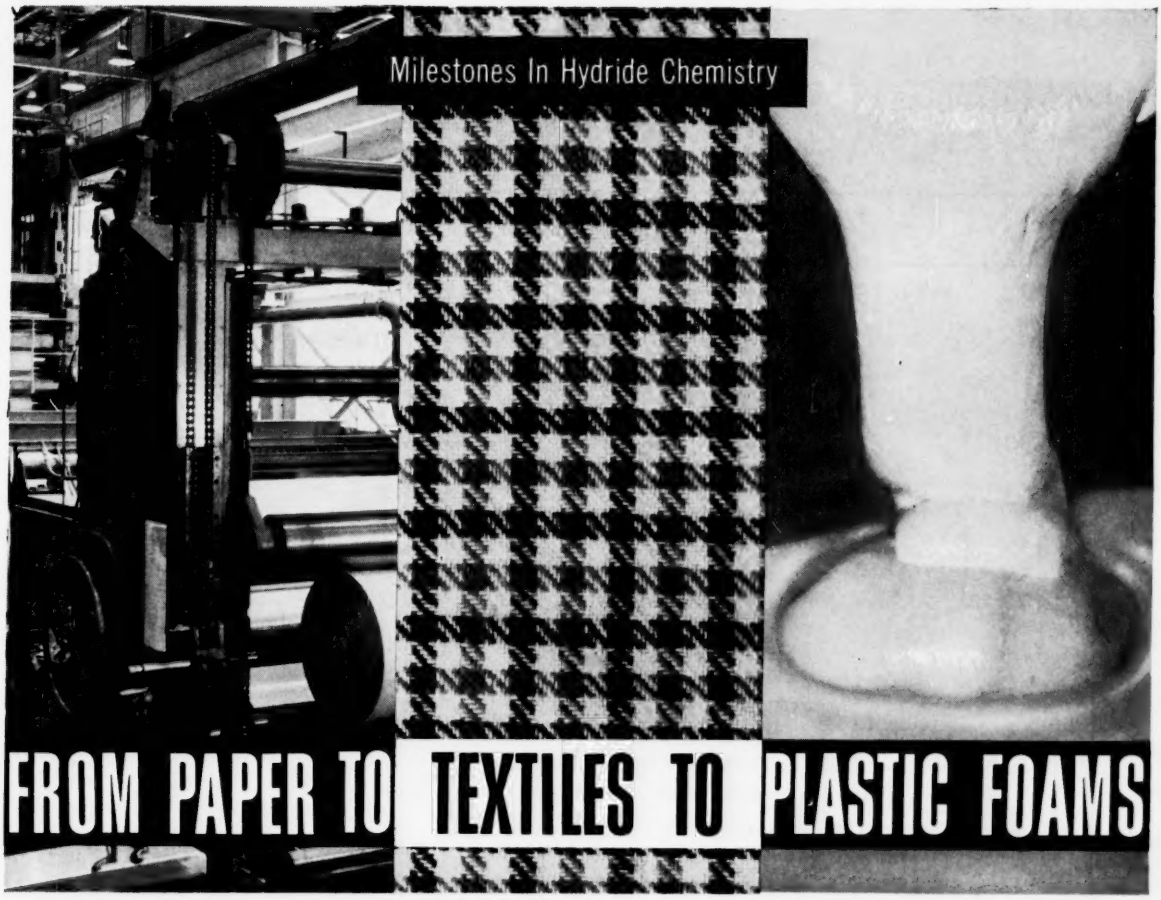
Dept. NT13-5-1, 40 Rector Street, , New York 6, N. Y.

(*Continued from p. 40*)

Industry Breakdown of 1959 Census of Chemical Process Plants*

Chemical Process Industry	Plants	Employees
Chemicals & Petrochemicals		
Alkalis & chlorine	46	30,581
Industrial gases	181	12,314
Cyclic (coal-tar) crudes	40	4,812
Dyes, dye (cyclic) intermediates & organic pigments (lakes and toners)	69	16,222
Industrial organic chemicals, n.e.c.	174	55,235
Industrial inorganic chemicals, n.e.c.	333	98,221
Synthetic rubber (vulcanizable elastomers)	35	16,728
Gum & wood chemicals	45	8,325
Chemicals & chemical preparations, n.e.c.	279	31,178
Total	1,202	273,616
Drugs & Medicines		
Biological products	34	7,137
Medicinal chemicals & botanicals	44	17,247
Pharmaceutical preparations	325	72,023
Perfumes, cosmetics & other toilet preparations	162	25,806
Total	565	122,213
Explosives & Fireworks		
Explosives	54	17,021
Ordnance & accessories, n.e.c.	17	8,800
Ammunition	30	45,084
Total	101	70,905
Fats & Oils		
Cottonseed oil mills	191	14,801
Soybean oil mills	70	6,142
Other vegetable oil mills	45	4,795
Grease & tallow	112	7,107
Fatty acids	12	1,822
Others	73	12,184
Total	503	46,851
Fertilizers & Agricultural Chemicals		
Fertilizers	309	24,580
Fertilizers, mixing only	76	4,479
Agricultural pesticides	86	5,500
Agricultural chemicals, n.e.c.	24	12,038
Total	495	46,597
Foods & Beverages		
Cane sugar refining	19	11,790
Beet sugar	49	10,595
Others	1,368	213,456
Total	1,436	235,841
Leather Tanning & Finishing		
Total	227	34,831
Lime & Cement		
Cement, hydraulic	161	40,753
Lime	58	6,073
Total	219	46,826
Man-Made Fibers		
Cellulosic man-made fibers	21	29,685
Synthetic organic fibers, except cellulosic	14	11,664
Total	35	41,349
Metallurgical & Metal Products		
Total	870	164,997
Paints, Varnishes, Pigments & Allied Products		
Inorganic pigments	50	10,651
Paints, varnishes, lacquers & enamels	566	56,367
Putty, caulking compounds & allied products	27	1,124
Total	643	68,142
Petroleum Refining & Coal Products		
Petroleum refining	302	148,521
Lubricating oils & greases	105	8,315
Coke & byproducts	54	133,142
Others	207	23,528
Total	668	313,506
Plastics Materials, Synthetic Resins & Nonvulcanizable Elastomers		
Total	215	71,335
Rubber Products		
Tires & inner tubes	81	103,493
Others	725	162,806
Total	806	266,299
Soap, Glycerin, Cleaning, Polishing & Related Products		
Soap & other detergents, except specialty cleaners	138	26,040
Specialty preparations	212	15,669
Surface-active agents, finishing agents, sulfonated oils and assistants	35	2,118
Total	385	43,827
Stone, Clay, Glass & Ceramics		
Glass (SIC Codes 3211, 3221, 3229)	279	140,188
Clay refractories	140	18,767
Abrasive products	126	30,716
Minerals & earth, ground or otherwise treated	171	16,165
Nonclay refractories	53	7,054
Others†	1,131	152,998
Total	1,900	365,888
Wood, Pulp, Paper & Board		
Pulp mills	56	37,475
Others	.....	253,824
Total	861	291,299
Other Products		
Glue & gelatin	78	6,343
Carbon black	38	3,670
Carbon & graphite products	26	7,785
Others	946	200,537
Total	1,088	218,335
Total Chemical Process Industries	**12,219**	**2,722,657**

* All plants with 20-or-more employees; † Statistics from U.S. 1954 Census; n.e.c., not elsewhere classified.



New Processing Applications for Borohydrides

In league with chemical processors around the world, MHI continues full tilt on the development of new applications for hydride chemistry. Application development for sodium and potassium borohydrides, for example, has opened exciting possibilities for chemists working in the pulp, paper, textile and plastic foam fields.

Reductive wood pulp bleaching

Sodium borohydride and potassium borohydride are being used effectively as reductive bleaching agents for wood pulp and cellulosic textile materials and for stabilizing bleached materials to prevent color reversion or yellowing. For the first time, chemists now have a water soluble reagent which will selectively and quantitively reduce the aldehyde groups in oxidized cellulose.

Textile finishers "clean up"

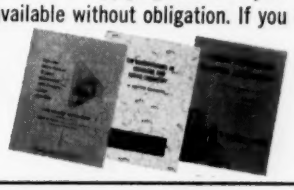
The borohydrides quantitively and rapidly reduce aldehydes and ketones to alcohols in water or alcoholic solutions at room temperature and atmosphere. The borohydrides "clean up" trace amounts of residual aldehydes in organic products, preventing odor development and greatly improving color stability for finishes using aldehyde-based resins. Borohydrides also reduce the carbonyl group in cellulose, introduced by oxidative bleaching, thus increasing resistance of the fibers to hot alkali.

Borohydrides make better foams

Borohydrides for producing vinyl foams offer versatile and inexpensive process possibilities using simple equipment. As blowing agents, the hydrogen yield of the borohydrides produces foams of fine, uniform cellular structure. Foam density is variable with the concentration of the borohydride. In addition to fine uniform cell structure, other advantages include low density, and low compression set.

New literature-technical service

Qualified technical service in applying the borohydrides to your process is available without obligation. If you do not now have these new MHI literature releases, write for copies now!



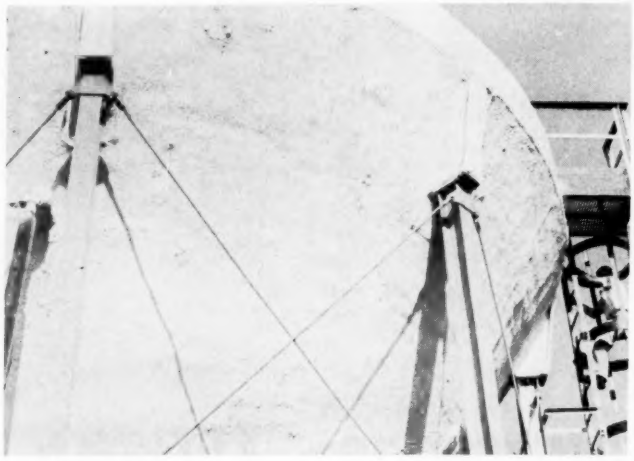
PIONEERS IN HYDRIDE CHEMISTRY

Metal Hydrides Incorporated

1102 WEST CONGRESS STREET, BEVERLY, MASSACHUSETTS

DEVELOPMENTS . . .

CHEMICAL PRODUCTS EDITED BY FRANCES ARNE



Plastic-Fluorocarbon Foam Spray Insulates Doubly

Wyandotte's research division with the De Vilbiss Co. has developed a portable low cost spray system producing rigid urethane foams with about twice the insulation efficiency of: fiberglass, cork or expanded polystyrene.

Members of Wyandotte's rapidly growing family of oxide products, used with fluorinated hydrocarbon gases, brought about a combination of materials which permits fairly low pressures for spraying. The K factor of this gas-containing foam is about 0.14 for a 2-lb./cu. ft. foam as compared with over 0.2 for conventional insulation. — Wyandotte Chemicals Corp., Wyandotte, Mich. 44A

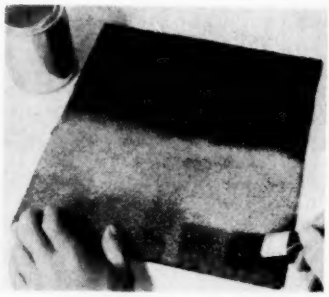
Transparent Ceramic

Porelessness is key to Al_2O_3 transparency.

A new ceramic has resulted from the removal of all the microscopic pores, or bubbles, that make conventional ceramics (at right) appear opaque. Named Lucalox, the highly dense material is made from aluminum oxide powder, pressed into shape and sintered. One can read through a polished specimen placed flat against printed matter. At greater distances it resembles frosted glass. At least 90% of the light in the visible spectrum is transmitted through it.

Lucalox possesses the high strength of alumina ceramics, stable at temperatures close to 3,600 F., can be pressed into any shape. No other material combines translucence with this degree of strength and heat resistance as well as ease of fabrication.

It is expected to extend the range of instruments and devices that is presently limited by the physical characteristics of available materials. An example: High-intensity incandescent and discharge lamps now limited, in some cases, by the heat-resistance of their transparent envelopes. — **General Electric Co., Schenectady, N. Y. 44B**



Polyurethane Coating

Permits reroofing without reshingling.

Old shingles are merely coated with a new polyurethane liquid resin, then sprinkled with ordinary sand, to endow them with many more years of waterproof service. Called Del-Coat, the resin is said to straighten curled and weatherbeaten wooden shingles.

Excellent abrasion and impact resistance and flexibility are claimed for the coating. To process asphalt shingles with polyurethane and sand, approximate cost of material and labor is **50-60¢/sq. ft.**, considerably less than that of complete renewal.—**Delka Research Corp., Bronx, N. Y. 44C**

(Continued on p. 46)

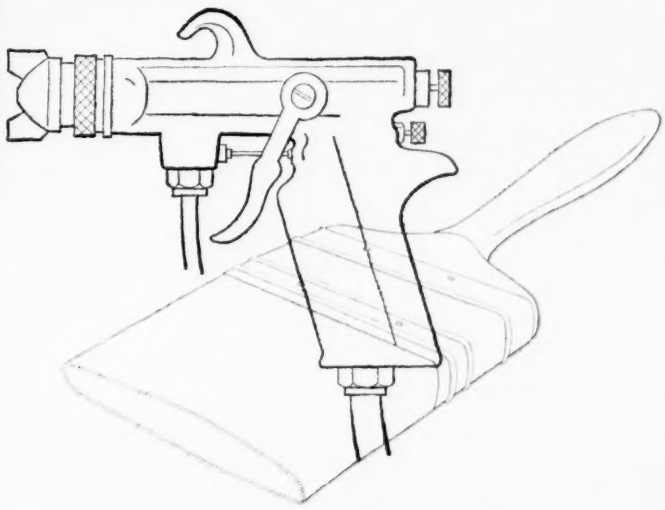
whatever the **process application . . .** you can depend on **CUNO** engineered filtration

In the paint industry, for example, manufacturers of enamels, varnishes, solvents, etc. know from experience that Cuno engineered filtration helps maintain efficient production . . . and is frequently the difference between good and *excellent* product quality.

All manufacturers in the process industries—from producers of pharmaceuticals to producers of petroleum products—depend on filtration. To meet their individual requirements Cuno furnishes a *complete* line of filter types:

- positive self-cleaning edge-type
- automatic self-cleaning wire wound
- disposable depth cartridge
- porous metal
- screen mesh

Let us apply over 30 years of filtration know-how to *your* requirements.



THE CUNO ENGINEERING CORP., DEPT. 14, MERIDEN, CONN.

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In Canada write: Peacock Bros., Ltd., P. O. Box 1040, Montreal 3, P.Q.

EXTRA STRENGTH of new firebrick, above, will increase rugged use. Ease of shaping, below, will lower costs.

Insulating Firebrick

Lightest in weight and lowest in thermal conductivity of any available.

Known as B&W K-20 and K-23, new insulating firebrick has been engineered to meet the rugged requirements of furnace builders and operators in the metals,. structural. clay,. oil, chemical and glass industries.

Mechanical strength of the refractory has been increased by more than 65% for K-20 and by more than 50% for the K-23. They can be fitted with hangers or pins without breaking.

The K-20 has an average weight of 1.70 lb. per 9-in. straight, while the K-23 9-in. straight averages 1.85 lb.—the only 2,300 F. use limit brick marketed today that weighs less than 2 lb. per 9-in. straight.

The B&W insulating firebrick can be tailor-cut, drilled or shaped as necessary, using ordinary wood-working tools. The need for costly special shapes and the delays involved in obtaining them is eliminated.—**Babcock & Wilcox Co., New York.** **46A**

Copper Paste

Produces printed wiring directly on ceramic, without adhesive.

By present methods for producing printed wire on ceramic, a sheet of copper foil is usually bonded to the ceramic or plastic base with an adhesive. The desired pattern is then produced by one of several methods usually involving the removal of undesired material. The bond of the copper to the base thus is dependent on the strength of the adhesive. Often, it fails during subsequent processing operations, such as soldering or assembly.

A new adhesive-less method is based on a specially formulated copper-bearing paste, uses standard silk screening techniques for forming the pattern. Paste is prepared from a finely ground mixture of copper oxide and a special glass frit, blended with a standard silk screen printing vehicle. The paste is used to print the pattern on the ceramic and the "card" is heat-dried to remove slovents. The card with its pattern is fired in air at 750 C. for 20 min. to burn off the printing vehicle. This leaves a nonconducting copper oxide pattern, ready to be reduced to metallic copper.

The second firing is at 850 C. for 30 min., in a controlled atmosphere containing hydrogen, nitrogen and oxygen. The hydrogen reduced the copper oxides to metallic copper; the oxygen prevents reduction of other oxides in the system and promotes good wetting of the glass frit and the ceramic. Without oxygen, a poor bond results.

Printed wiring cards prepared this way can be dip-soldered without bond failure, and without use of corrosive fluxes.

The process is suitable for automatic production techniques, and should prove competitive in cost with other printed wiring methods.—**Bell Telephone Laboratories, New York.** **46B**

(*Continued on p.* 48)

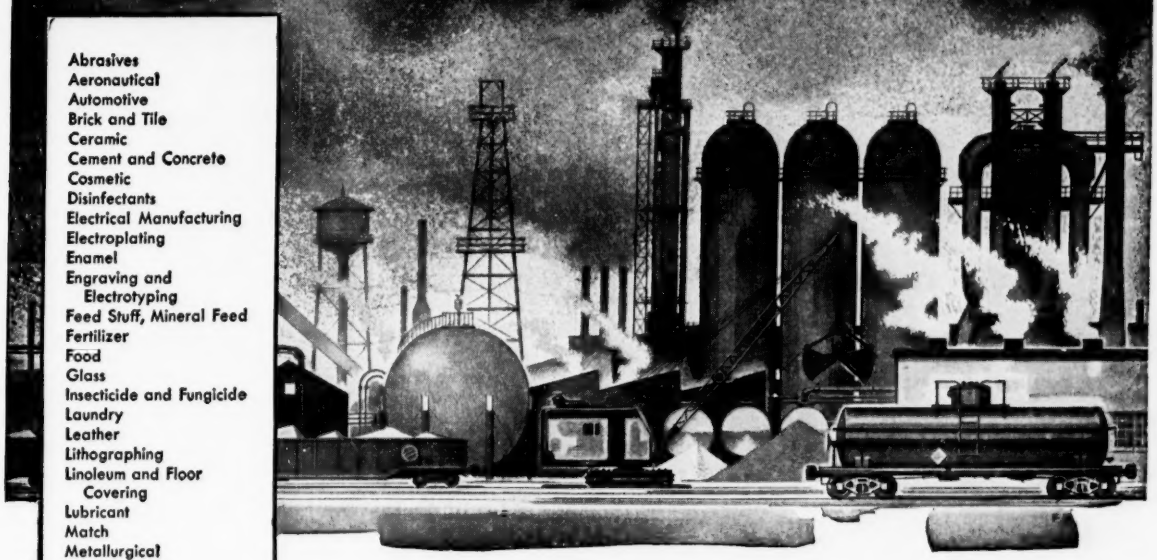
Newsworthy Chemicals

Page Number is also Reader Service Code Number

Urethane-fluorocarbon foam spray insulates doubly..... **44A**
Transparent ceramic has high strength, heat stability..... **44B**
Urethane coating permits reroofing without reshingling..... **44C**
Firebrick combines light weight, low thermal conductivity.... **46A**
Copper paste produces printed wire without adhesive..... **46B**
Vinyl film seals off surgical wounds..... **48A**
Polyethylene does not retain dust-attracting charge..... **48B**
Epoxy paving, which resists jets, gets plant use..... **48C**

For more details, use Reader Service Card

IS YOUR INDUSTRY LISTED HERE?



- Abrasives
- Aeronautical
- Automotive
- Brick and Tile
- Ceramic
- Cement and Concrete
- Cosmetic
- Disinfectants
- Electrical Manufacturing
- Electroplating
- Enamel
- Engraving and Electrotyping
- Feed Stuff, Mineral Feed
- Fertilizer
- Food
- Glass
- Insecticide and Fungicide
- Laundry
- Leather
- Lithographing
- Linoleum and Floor Covering
- Lubricant
- Match
- Metallurgical
- Metal Working
- Oil Cloth
- Optical
- Paint, Varnish and Lacquer
- Paper
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- Plastics
- Pottery
- Printing Ink
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- Glycerine
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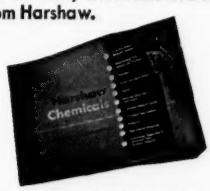
- Synthetic Optical Crystals
- Agricultural Chemicals
- Fungicides
- Chemical Commodities

FREE! This 16-page booklet lists the many chemicals available from Harshaw.



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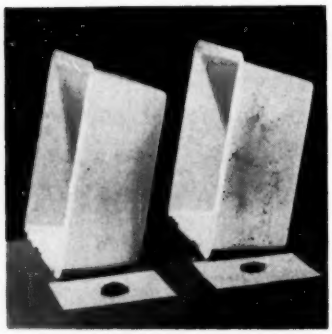
Skintight Vinyl Film Seals Off Surgical Wounds

Clear vinyl film 0.002 in. thick is finding use as a surgical drape to reduce operating room infections. The surgeon makes the incision through a skintight plastic sheet which covers the area of the operation. The operating wound is sealed off from bacterial contamination from the patient's own skin, a primary source of infection in surgery.

The film replaces towels or other porous material which are much less effective sealants.—Union Carbide Plastics Co., New York. 48A



Polyethylene

Unlike conventional product, right, does not retain dust-attracting charge.

Two new polyethylene compounds have been developed which eliminate dust attraction by injection molded articles. A molded piece of the new material is shown beside a piece of conventional polyethylene, left to right, above. Each piece was rubbed with a cloth and set down before a piece of cigarette ash. Because the new polyethylene does not retain the electrical charge, it did not attract the dust.

The new materials are designated Bakelite polyethylene DNDA-0401 and DPD-7366. DPD-7366 is based on a new polyethylene copolymer which has excellent low-temperature toughness and improved rigidity in addition to its anti-dust properties. DNDA-0401 is a high flow general purpose anti-dust housewares material with less rigidity than DPD-7366, in molded housewares items. Compounds are expected to find application in items ranging from tumblers to 20-gal. refuse cans. **—Union Carbide Plastics Co., New York. 48B**

Epoxy Paving

Nearly indestructible surface, developed for jet runways, gets plant use.

Aimed originally at meeting severe conditions imposed by new jet aircraft on airport runway and maintenance area pavements, Epon asphalt concrete is shown above as it is applied to a roadway at Shell's Houston plant.

It combines petroleum asphalt, petroleum-derived epoxy resins and a plasticizer, can withstand the hot blasts of jet engine exhausts and the solvent action of spilled jet fuel, gasoline, hydraulic fluids, cleaners.

Though cost is about 10% higher than regular asphaltic concrete, the new compound's long life span plus susceptibility to conventional methods of application should open wide markets to it.

Shell has also been engaged in developing highway and bridge surfacing materials which utilize epoxy resins' nonskid properties. — **Shell Chemical Co., New York. 48C**

For More Information . . .

about any item in this department, circle its code number on the

Reader Service

postcard (p 145)

NEW EVAPORATOR SPEEDS GELATIN PRODUCTION

Gelatin, like other heat sensitive food products must be processed quickly if a pure, high-quality product is to be obtained. The double-effect, long-tube, vertical Swenson evaporator shown above was specially engineered for minimum product retention. A 3 per cent gelatin solution is processed at the high rate of 11,500 lbs. per hour, yielding a top-grade 20 per cent solution required for drying. A thorough understanding of the problem, careful planning and engineering, and the finest construction produced this efficient, stainless unit, adaptable to the processing of many food products. Its quality is typical of all Swenson equipment for the food, chemical, and petroleum industries. Whatever your needs in evaporators, spray dryers, crystallizers, or special equipment, call on your Swenson engineer.

WRITE for more information on Swenson evaporators. Ask for Bulletin E-100.
Swenson Evaporator Company, 15669 Lathrop Avenue, Harvey, Illinois

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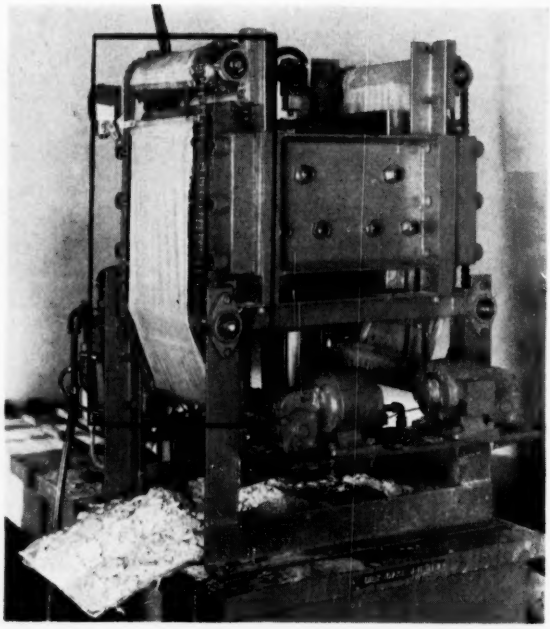

For schematic of operation, please turn page.

Two-Belt Filter Scores Big Output

Feeding on hard-to-handle slurries, this unconventional filter automatically turns out thin, dry cakes at unusually high rates.

If you are fortunate enough to attend the New York Chem Show later this month, it might be worth your while to visit Read Standard's booth and see their unique Short-Cycle filter.

Technically classified as an automatic, cyclic pressure filter, this novel machine can be best compared to a plate-and-frame press. However, instead of the usual 20 to 40 chambers, Short-Cycle has only two, with a total filtration area of about 1.6 sq. ft. Two endless belts of filter medium, one passing through each chamber, are automatically repositioned following completion of each cycle.

▶ **Versatile Operation** — Total cycle time for precoat (if necessary), filtration, washing, drying and discharge varies with application, but seldom exceeds 30 to 90 sec. Any combination of these intermediate steps, as well as multiple washings, can be quickly programmed into the cycles.

According to Read Standard, Short-Cycle units will prove to be most economical for filtration of hard-to-handle slurries —those in which the solids are amorphous or extremely small in particle size. Changeover from one feed to another requires no extensive, time-consuming cleaning procedures;

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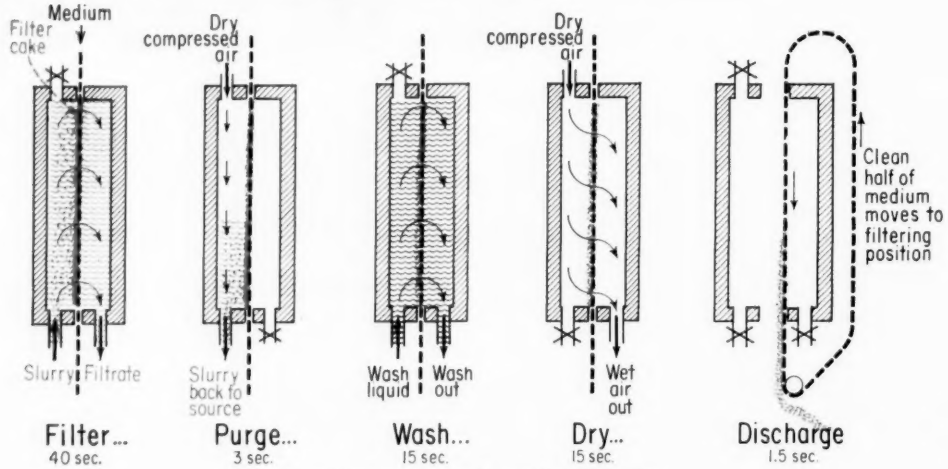
Cyclic Filter Operation—cross section of one filter chamber



Times shown are representative of typical operation

media blinding is not a problem.

Since the thin cakes produced have a uniform structure and are porous, highly efficient washing takes place. Drying to very low, controlled, moisture contents is possible for the same reason.

▶ **High Filtration Rate**—Requiring only 10 sq. ft. of floor space, Short-Cycle units can frequently outperform plate-and-frame or rotary filters many times their size. Typically, they can deliver up to 1,000 lb./day of relatively dry cake and clear filtrate from slurries having a solids content below 50%.

In one application study, Read Standard compared the performance of their machine with a rotary vacuum filter equipped with compression blankets. Feed to both units was a 25% slurry of ferrous oxide in water.

Yield of thixotropic cake from the rotary filter was 12 lb./(sq. ft.) (hr.), with a moisture content of 70%. Production rate of the Short-Cycle was 75 lb./(sq. ft.) (hr.) with 63% moisture.

Short-Cycle filters can also do a good job of polish-filtering if an automatic precoat step is included in the cycle. As a guide to polishing capacity, Read Standard quotes a throughput of about 3 gpm. for feed solutions containing 1% fibrous solids.

▶ **Control Via Pressure**—Filtrate flow through a forming cake on any conventional filter varies with change of cake thickness. As the cake builds, pressure on the slurry side of the media rises and filtration rate declines—first gradually, then sharply.

A pressure switch limits operation of Short-Cycle machines to only the peak, or gradual part, of a typical filtration curve. Such operation retards both compaction of the cake and crystal collapse, thus maintaining high filtration efficiency. It also facilitates subsequent washing, drying and discharge.

▶ **Operation**—Raw slurry enters the two chambers, a pressure drop develops, and filtration starts. (See the schematic illustration above) As soon as the cake builds to a thickness sufficient to trigger the pressure switch, the feed valve closes, and an air purge forces unfiltered slurry back to its source.

Wash liquor enters the chambers and flows through the cakes. At the end of the wash cycle, as controlled by a timing relay, another air purge empties the chambers. Then the air-drying step commences, if required. Finally, an air-actuated cam, which holds the chambers closed against spring tension, retracts; this frees the media belts, which rotate through one-half of a revolution.

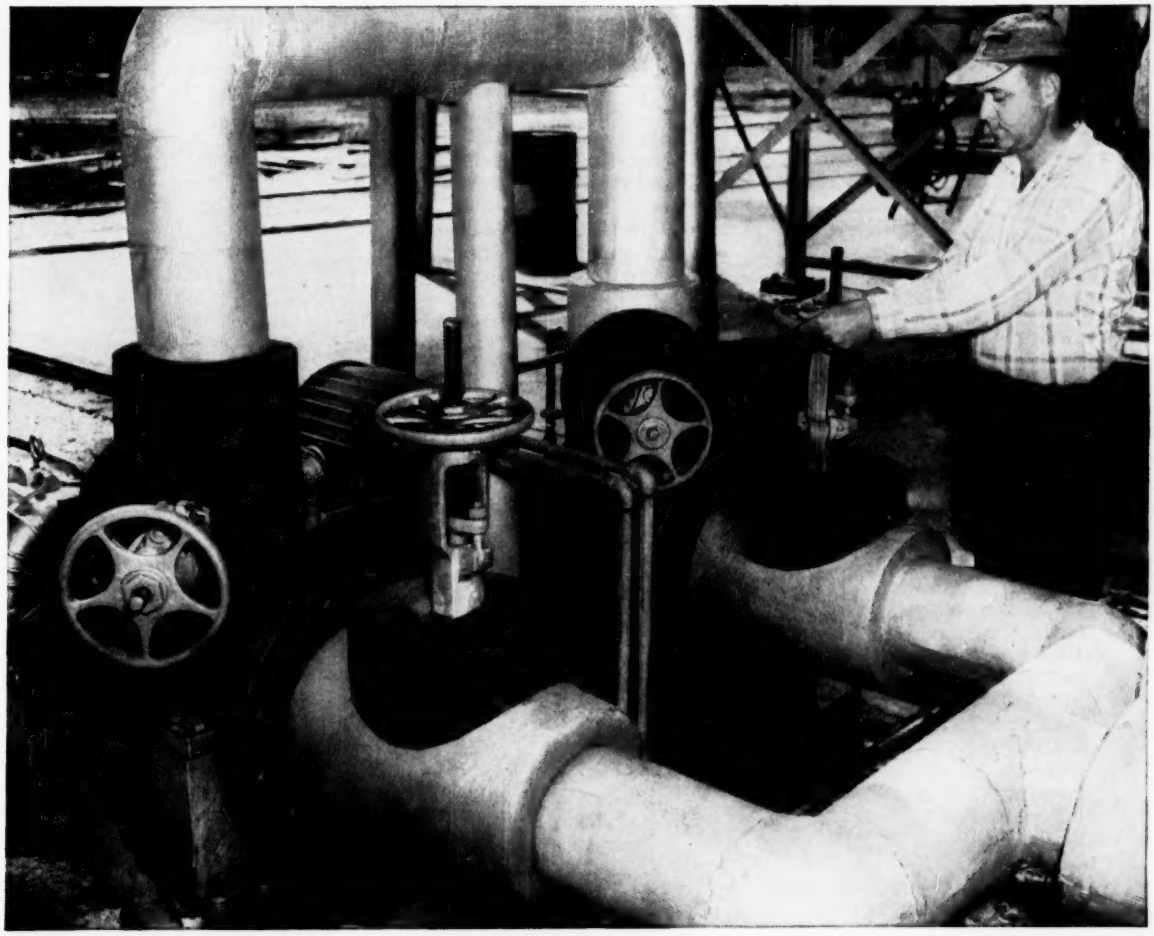
As the moving belts pass over a small-diameter roller, the cake discharges. The cam then closes the chambers, and the cycle repeats.

▶ **Industrial Acceptance**—Thus far, four Short-Cycle filters have been installed. Another 20 machines are under current negotiation.

One of Read Standard's customers, Lord Chemical of York, Pa., finds the machine quite effective for pre-discharge cleanup of waste effluents containing metal hydroxides and calcium soaps. Another customer, an Eastern toilet-goods manufacturer, has put a Short-Cycle to work polish-filtering shampoos.

▶ **Availability**—Short-Cycle filters come with a wide variety of construction materials. They can use virtually any kind of fabric or wire media. Price of a stainless steel unit is in the $5-6,000 bracket, including valving and control panel.—**Read Standard, Div. of Capitol Products Corp., York, Pa. 50A**

Equipment news continues on p. 54



Holding tight on Dowtherm . . .

one of many jobs Crane Steel Gates do better

For more than four years these Crane 33XR 300-pound steel gate valves have given the Crosby Chemicals plant at Picayune, Miss., completely trouble-free service on 500 F Dowtherm. And they're still in perfect working order!

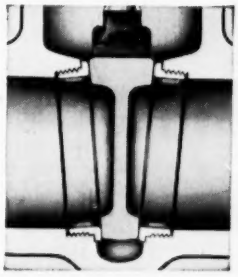
The hard-to-hold and non-lubricating characteristics of Dowtherm pose no problem for these valves. Seating materials—Crane Exelloy to No. 49 nickel alloy—insure the highest resistance to galling, wear and erosion.

A long-lasting, tight stem seal is made with special packing for Dowtherm—and Crane steel castings give the body and bonnet extra strength and rigidity for sustained smooth and positive operation under toughest working conditions.

On Dowtherm, steam, oil, gas or any service, you can rely on Crane steel gates for out-of-the-ordinary durability and maintenance savings. Their competitive price offers values you can't afford to overlook. Get full facts from your local Crane branch or wholesaler—or write to address below.

PROOF that Crane quality is better

Get "Valve Performance Facts"—a booklet of 32 case histories on Crane installations. Gives you many ideas for valve savings. Your copy free on request.



T-head disc-stem connection prevents lateral strains on stem. Close-fitting disc guides maintain accurate seating, reduce wear.

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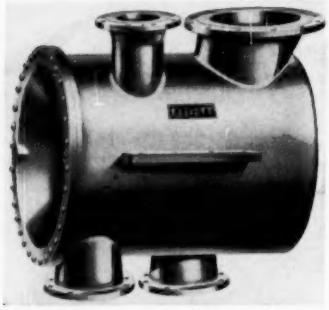


Centrifugal Compressors

Free from vibration or any flow pulsations.

Available in both single- and two-stage designs, a new line of centrifugal compressors for low-flow, high-pressure applications features simple design, flexibility in materials of construction, and adaptability to gases other than air. Capacities range from 800 to 8,000 cfm., pressures to 1,000 psi.

Designated Type R, the compressors have special bearing housings and seals to permit lubrication with water or other fluids. This obviates explosion hazards caused by oil contamination or toxic-gas leakage. Foundation requirements are simple and inexpensive.—**Elliott Co. Jeannette, Pa. 54A**

Power Level Gage

Force balance system detects liquid levels.

In the past, there have been attempts to popularize power-driven liquid-level gages, but in the usual case, cost factors made commercialization prohibitive. Vapor Recovery Systems Co. has now brought out a unit that, they claim, will bring costs within striking distance of conventional automatic tank-gage installations.

Called the Dynamatic, the device eliminates friction and other problems occasioned by floats, counterweights and spring balances. A servomotor handles all movements within the system. Accuracy is better than $\frac{1}{32}$ in.; sensitivity is better than $\frac{1}{64}$ in.; and repeatability is better than $\frac{1}{32}$ in.

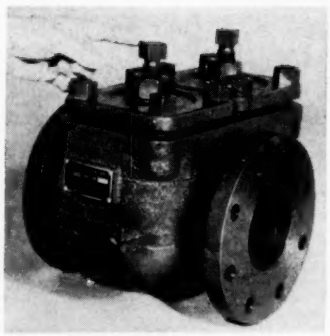
Dial and counter come graduated in feet, inches and 16ths; feet and hundredths; inches and tenths; and the metric system. —**Vapor Recovery Systems Co., Compton, Calif. 54B**

Control Valves

For vacuum applications involving high flows.

A new line of diaphragm-operated valves, designed for high-flow vacuum processing applications, is capable of sealing and holding vacuum to within 0.5 in. Hg absolute for an indefinite period of time. All models feature resilient, synthetic O-ring seat seals combined with direct metal-to-metal seat stops to assure positive sealing.

Material of construction for valve bodies is bronze; stems are Monel; trim is stainless steel. Sizes to 3 in. NPT. Flange or screw mountings.—**The Sinclair-Collins Valve Co., Akron, Ohio. 54C**



Check Valves

Air-cushion design dampens line pulsations.

Rugged, simple construction of Airchek valves provides long service life and negligible maintenance. Inspection is easy because internal parts are accessible on removal of the cover, without breaking piping.

Flat, annular, stainless steel disks, guided at their outer periphery, lift against a cushion of air or gas. This cushioning action eliminates "slam," which is sometimes common to conventional check valves. Design of the valve seat dampens pulsations present in compressor discharge lines.

Airchek valves install in any position. Sizes are available for $\frac{3}{4}$- to 12-in. discharge lines, and for pressures to 600 psi.—**Pennsylvania Pump & Compressor Co., Easton, Pa. 54D**

Induction Motors

For applications calling for high speed, power.

Ratings of a new line of large a.c. induction motors in open dripproof enclosures range from 150 to 2,000 hp. at 1,800 and 3,600 rpm. Special design emphasis on the ventilation systems assure minimum motor-noise levels.

Pressure lubrication systems

For More Information

about any item in this department, circle its code number on the

Reader Service

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EQUIPMENT NEWS Continues on . . . **Page 130**

MODERNIZING?
PLANNING A DRYING SYSTEM?

ADD
ALL COST FACTORS...

INITIAL COST
INSTALLATION
MAINTENANCE
OPERATING COST
DELAYED PRODUCTION
WASTE

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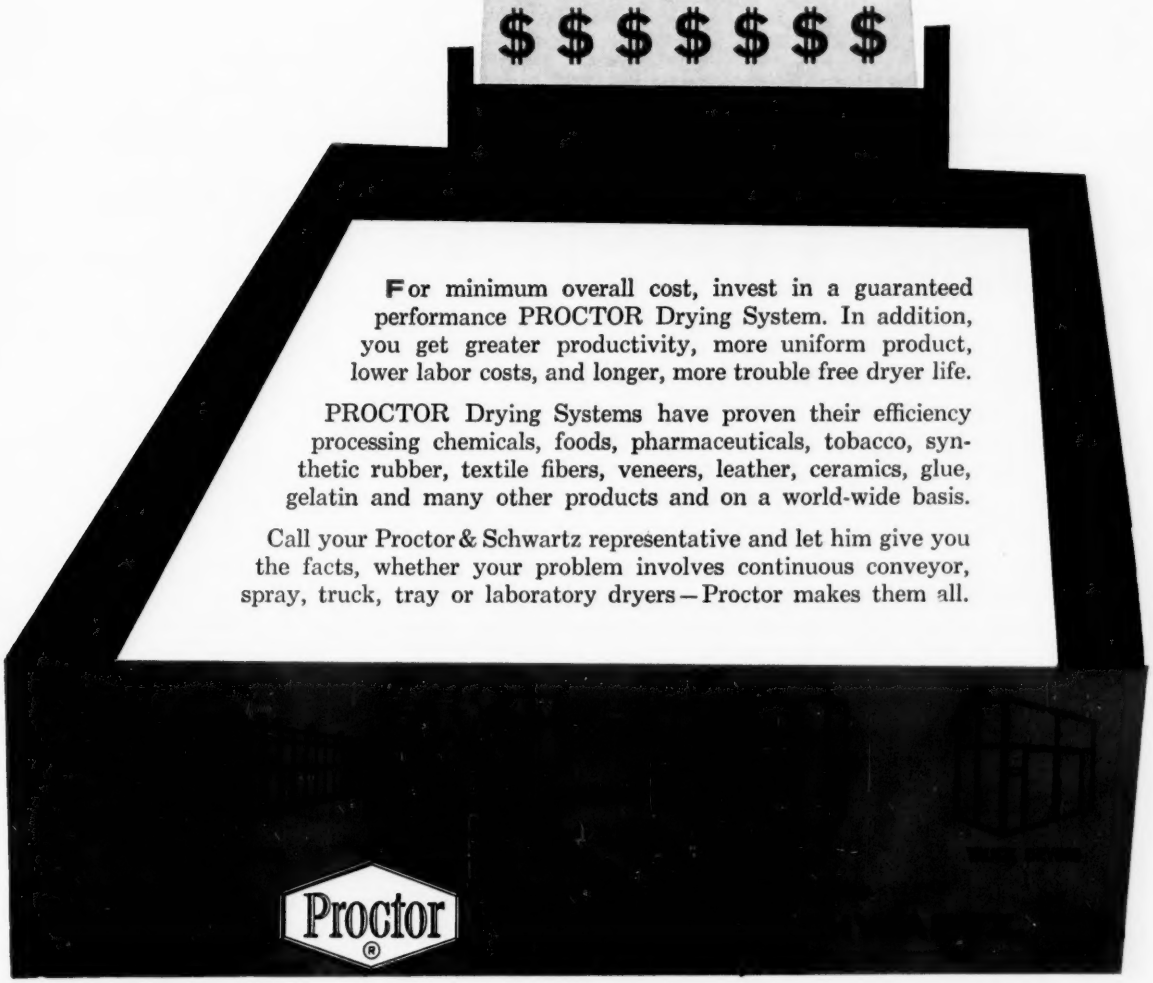

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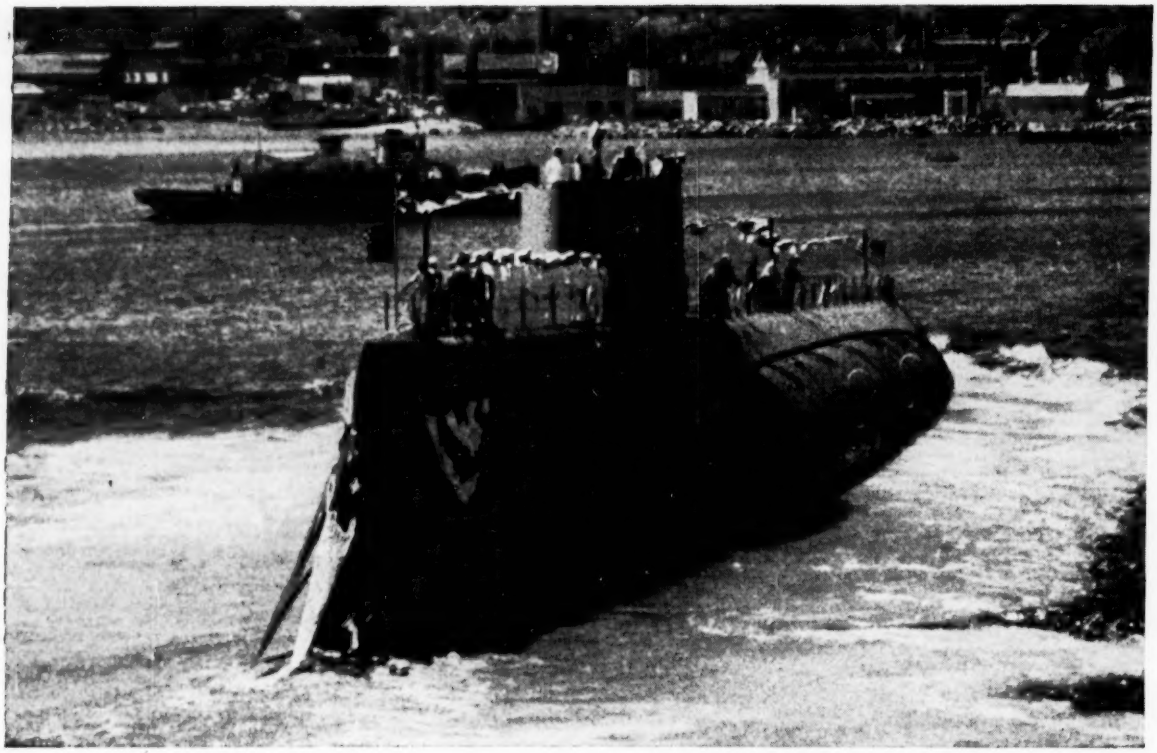


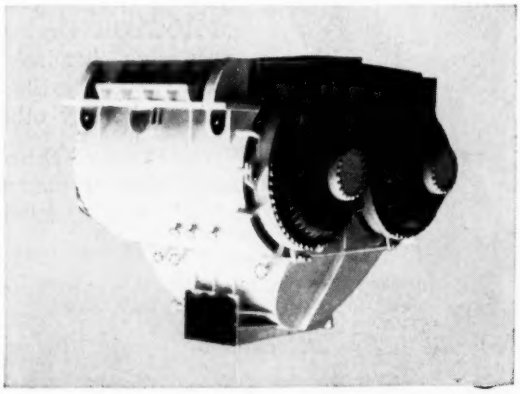
Triton, Navy's Largest Nuclear Sub, Uses Bridgeport Condenser Tubes

Launched in August, 1958, the U.S.S. *Triton* is the biggest, most powerful submarine ever built. With a length of 447 ft. and a displacement of 5,900 tons, *Triton* boasts, among other things, of two engine rooms and two reactor compartments. Built by the Electric Boat Division of General Dynamics Corporation, she is truly a major achievement in naval architecture.

Naturally, *Triton's* equipment must meet the most rigid operating requirements. Helping to fulfill these requirements are Bridgeport Cupro-Nickel condenser tubes in the Allis-Chalmers condenser and air ejector equipment.

Meeting operating demands such as *Triton's* has long been standard practice at Bridgeport. Outstanding operating records have been—and are being—achieved regularly. The experience and knowledge gained from these records can be put to your use—whenever you wish to take advantage of them.

Whatever your needs—simple retubing or other requirements—they are best served, in every respect, by Bridgeport. If you have any problem, question or plans involving heat exchanger equipment, on land or at sea, call your nearest Bridgeport Sales Office. For full details, write direct for the 162-page Bridgeport Condenser Tube Handbook. Write Department 5012.



These twin condenser units were designed and built by Allis-Chalmers. Bridgeport tubes were used throughout.

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Sometimes we can . . . and sometimes we can't. It depends, of course, on the nature of the problem at hand.

But this much we're sure of: We can save you time in many ways with information on our products that we've gained from our own experience and that of others in consumer industries.

For example, we can furnish data on chemical, physical, physiological and toxicological properties, product specifications, sound handling and storage practices and precautions, product limitations and other such characteristics on Wyandotte products wherever they are pertinent. We can make specific recommendations as to the best ways to use Wyandotte products and fit them into your profit picture.

We can also aid in your choice of the proper processing equipment, check your handling and unloading systems, inspect your storage facilities, and instruct your personnel on safety measures as related to our products.

In this way we save you valuable research and laboratory time . . . eliminate duplication of effort . . . insure your getting the maximum performance from our products.

Wouldn't you call this kind of technical service deep-rooted and sincere?

Well, if you do, and you need information on any of the many chemicals that are within our manufacturing range, contact us. To expedite our action, be sure to furnish as much information as possible . . . the extent of our help is in direct proportion to our realization of the customer's complete problem.

For a pictorial presentation of Wyandotte technical service at work, please turn page.

WYANDOTTE CHEMICALS

SODA ASH • CAUSTIC SODA • BICARBONATE OF SODA • CALCIUM CARBONATE • CALCIUM CHLORIDE • CHLORINE • MURIATIC ACID • HYDROGEN • DRY ICE • GLYCOLS
SYNTHETIC DETERGENTS (anionic and nonionic) • SODIUM CMC • ETHYLENE OXIDE • ETHYLENE DICHLORIDE • POLYETHYLENE GLYCOL • PROPYLENE OXIDE
PROPYLENE DICHLORIDE • POLYPROPYLENE GLYCOL • DICHLORODIMETHYLHYDANTOIN • CHLORINATED SOLVENTS • OTHER ORGANIC AND INORGANIC CHEMICALS

CHLORINE CARE

. . . an example of Wyandotte technical service at work

1 A Wyandotte technical service man really gets around. Here, he checks a chlorine distillation test in our analytical laboratory. Each producing plant has its own analytical laboratory, where controls are set up to help guarantee customer satisfaction.

2 Out on the tracks, he assists in all phases of safe handling procedures. Note the caution signs, safety platform, and flexible loop. These are just a few of the precautions that personnel handling chlorine should always follow to insure safety.

3 In our application-research laboratory, he examines the results of pulp bleaching tests. This customer had a difficult bleaching problem, and new procedures, developed by Wyandotte's application research, proved extremely helpful in finding a solution.

4 At the customer's mill, he inspects the bleach equipment. Here, his knowledge and experience gained in the laboratory are applied. A technical service man's work can take him anywhere . . . wherever there is room for progress or improvement.

Wyandotte
CHEMICALS

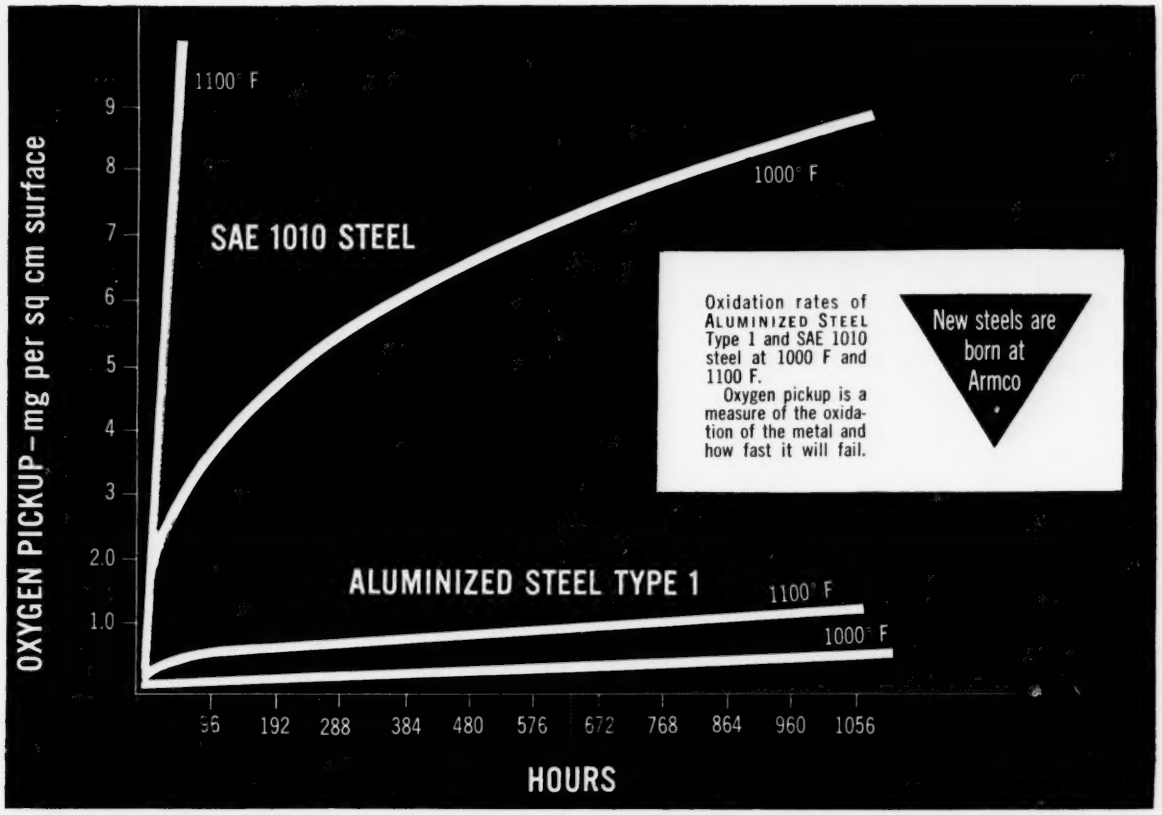
Pacing progress with creative chemistry

As you can see, chlorine requires a lot of care . . . in many respects . . . from manufacture to delivery and ultimate use. Wyandotte technical service is flexible enough to offer our customers a lot of help with this job. And on many other jobs, too. If you have a problem that falls within our technological or manufacturing background, check with us . . . our approach is designed to provide answers. *Wyandotte Chemicals Corporation, Michigan Alkali Division, Wyandotte, Michigan. Offices in principal cities.*

721

ARMCO STEELS / for chemical processing

Research data show why Armco's Aluminum-Coated Steel withstands heat



Oxidation rates for ALUMINIZED STEEL Type 1, contrasted with those for SAE 1010 steel, reveal why this special hot-dip aluminum-coated Armco Steel is used in a wide variety of chemical processing equipment.

Applied by a special Armco-developed process, the aluminum coating prevents destructive scaling at temperatures up to about 1250 F. Service in chemical plants demonstrates that ALUMINIZED STEEL Type 1 also effectively resists the combination of heat and corrosion. And because its steel base gives parts high strength and rigidity, ALUMINIZED STEEL can be used in thinner gages and at higher temperatures than other metals.

This unique two-in-one Armco Steel provides much longer service life than any other metal in its price class. That's why it is specified for carbon black burner shields, stack shields, reactor covers, fume oxidizers, engine mufflers, ovens, and similar processing equipment.

For complete information about Armco ALUMINIZED STEEL Type 1, write Armco Steel Corporation, 3309 Curtis Street, Middletown, Ohio.

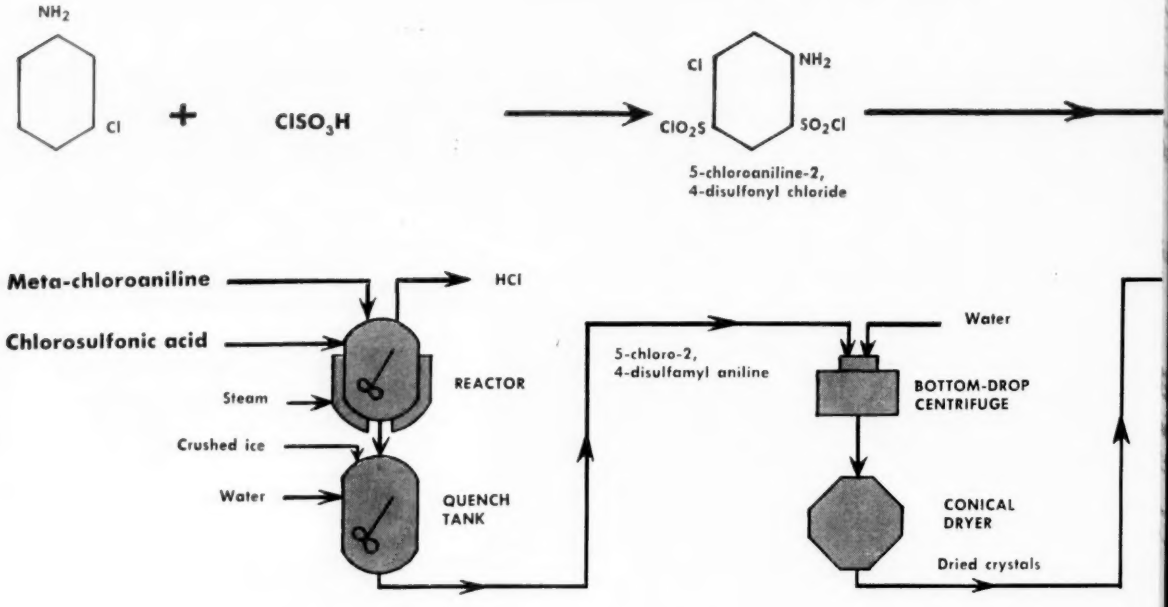
ARMCO STEEL

Armco Division • Sheffield Division • The National Supply Company • Armco Drainage & Metal Products, Inc. • The Armco International Corporation • Union Wire Rope Corporation

DEVELOPMENTS . . .

PROCESS FLOWSHEET

R. A. LABINE



Engineering the Diuril Process

Merck's Diuril is a real breakthrough in drug research. Here is the first detailed description of its manufacturing process.

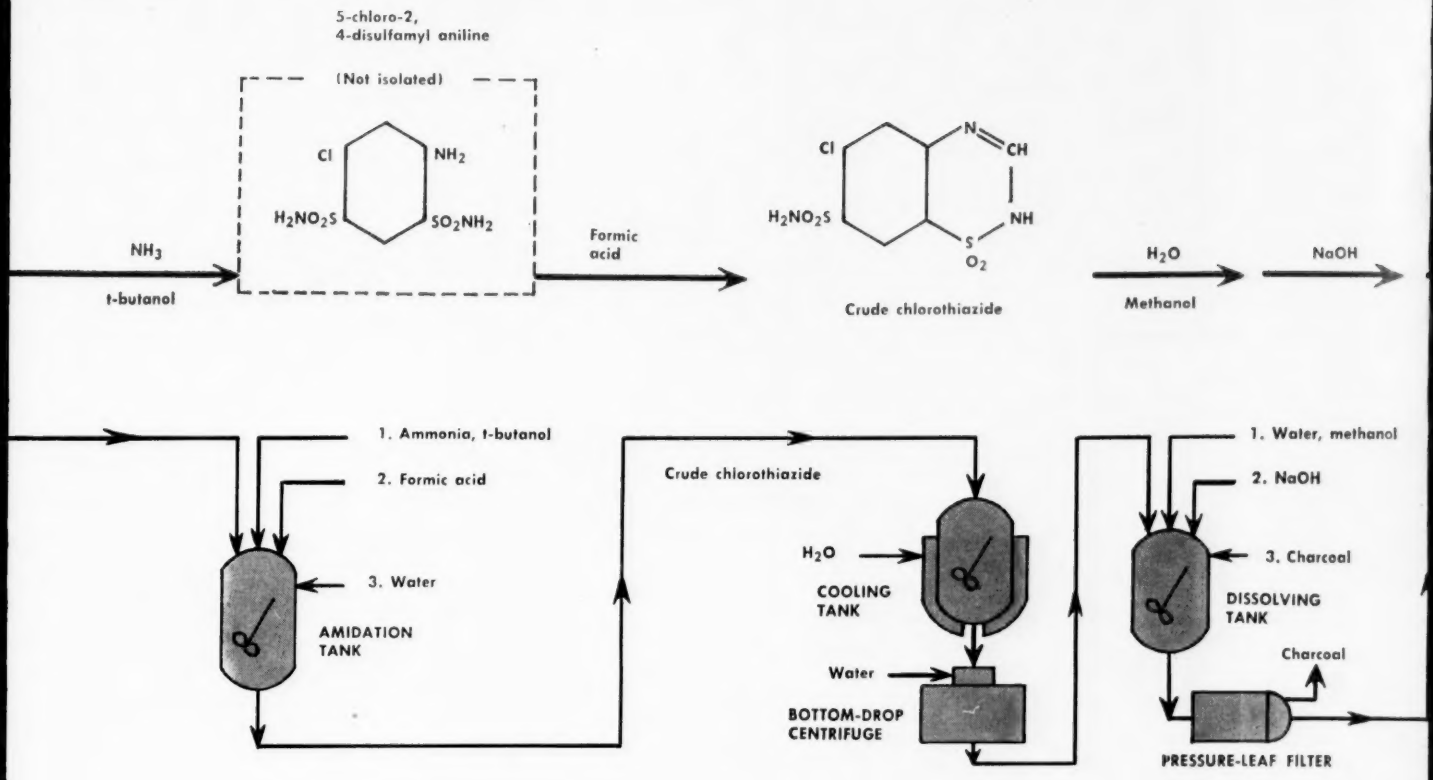
"BETWEEN October 1957 and June 1958 when the Diuril plant came on stream, we had to revise design capacity upward several times until we had finally doubled the original figure—at the same time utilizing the provided equipment and instrumentation at maximum efficiency." Thus does a Merck & Co. engineer describe the challenge of designing a production plant for a fast-selling new drug.

Diuril (chlorothiazide), introduced commercially in January 1958, is effective in combating hypertension and various diseases accompanied by excessive accumulation of body fluid. Too, advent of Diuril has sparked research on similar diuretic compounds, such as the work that was reported at the American Chemical Society meeting in Boston last spring.

▶**Fine Chemical Engineering**—Despite the inevitable pressure to have a production unit on stream "yesterday," designers of a drug process have to also keep an eye on future requirements. In the Diuril process, there were several additional problems:

Drying crystals of disulfonyl chloride (a process intermediate) is tricky because it is highly corrosive and decomposes above 140 F. Using a

Unfold Flowsheet



glass-lined conical vacuum dryer, drying time was cut to 6-7 hr. at close to 140 F. giving crystals with only 0.1% moisture.

Off-gas from the chlorosulfonation step contains HCl plus "other acidic impurities" which required the design of a special scrubbing system to water-absorb all the vapors. Too, there were several late changes in the process which increased yields by 50% (to "a rather respectable value") and which had to be incorporated into the design.

At the Albany, Ga., Diuril plant, all vessels are glass-lined and extensive use is made of glass piping to maintain product purity.

▶**Four-Stage Process**—Diuril is produced from meta-chloroaniline in four steps: (1) production of 5-chloroaniline-2, 4-disulfonyl chloride from meta-chloroaniline and chlorosulfonic acid; (2) amidating with anhydrous ammonia to 5-chloro-2,4-disulfamyl aniline; (3) ring closure with formic acid to produce crude chlorothiazide; (4) recrystallizing to produce pure Diuril.

For initial reaction, chlorosulfonic acid and meta-chloroaniline are pumped to calibrated metering tanks fitted with overflow lines so that quantity of reactants charged is always the same. Meta-chloroaniline is then added slowly to the chlorosulfonic acid in the reactor. After completion, reaction mass drains into the quench tank where crushed ice is added and 5-chloroaniline-2,4-disulfonyl chloride precipitates. These crystals are centrifuged and dried in an 8-ft. conical dryer.

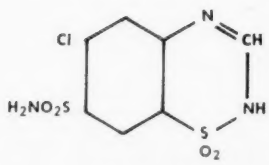
▶**Closing the Ring**—Crystals from first reaction are charged to amidation reactor along with tertiary butanol. Adding anhydrous ammonia forms 5-chloro-2,4-disulfamyl aniline. To make chlorothiazide, formic acid is added to the products at 400 F. which closes the ring.

Total precipitation of crude chlorothiazide is obtained by quenching reaction mass in water. Quenched mixtur
then through a
arate chlorothiazi
acid and reaction

▶**For High Purity**
crystallization of
pure Diuril.

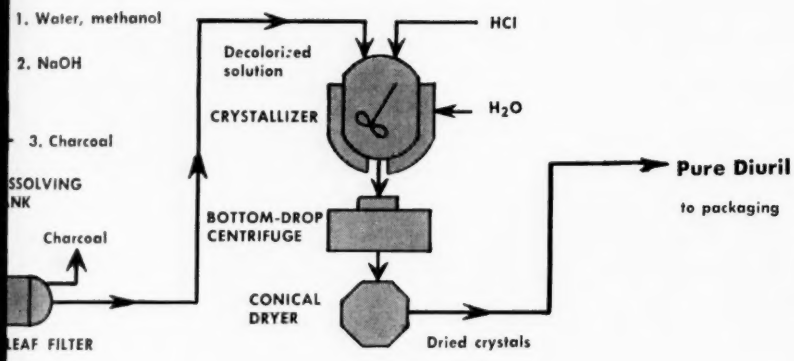
To water and
is added the crud
hydroxide is adde
activated charcoa
solution. Mixture
leaf filter until filt
to the crystallizer
"pure room."

Addition of HCl
lizer precipitates p
tals are washed,
packaged in polyet
ing, pure Diuril is



NaOH → Charcoal → HCl

Pure chlorothiazide (Diuril)



Quenched mixture flows to a cooling tank and then through a bottom-drop centrifuge to separate chlorothiazide crystals from excess formic acid and reaction liquor.

For High Purity—Final step in process is recrystallization of crude chlorothiazide to give pure Diuril.

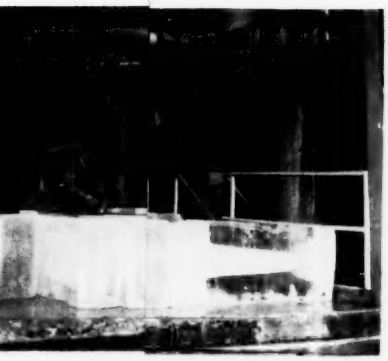
To water and methanol in the dissolving tank is added the crude chlorothiazide. Dilute sodium hydroxide is added until all crystals dissolve, then activated charcoal is charged to decolorize the solution. Mixture recycles through a pressure leaf filter until filtrate is clear and then it diverts to the crystallizer in the closed, air-conditioned "pure room."

Addition of HCl to the cool solution in crystallizer precipitates pure chlorothiazide. These crystals are washed, centrifuged, dried, sifted and packaged in polyethylene-lined drums. After testing, pure Diuril is shipped to the tableting plant.

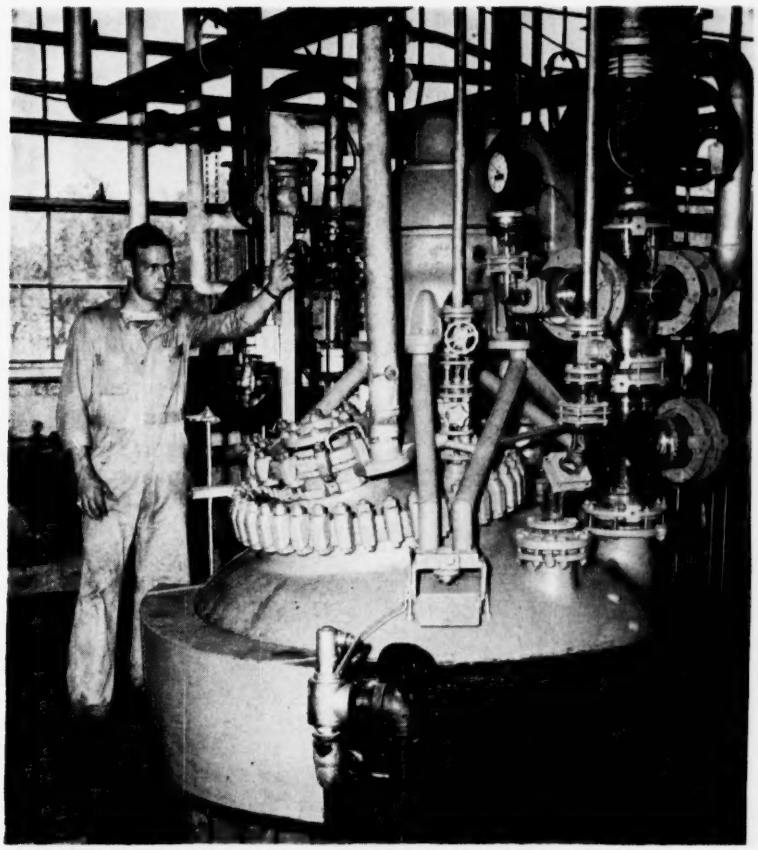
REACTOR wher
lined to prevent

ICE BLOCKS ar
conveyed to the

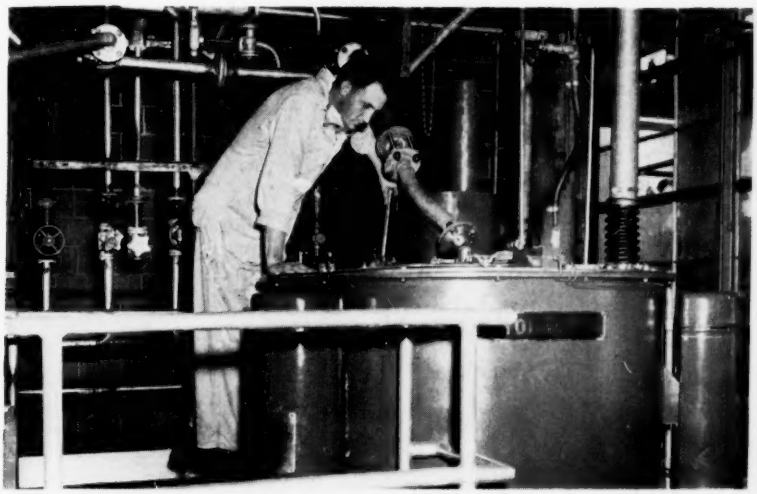
where first rea n is carried out is glass-
vent corrosion product contamination.



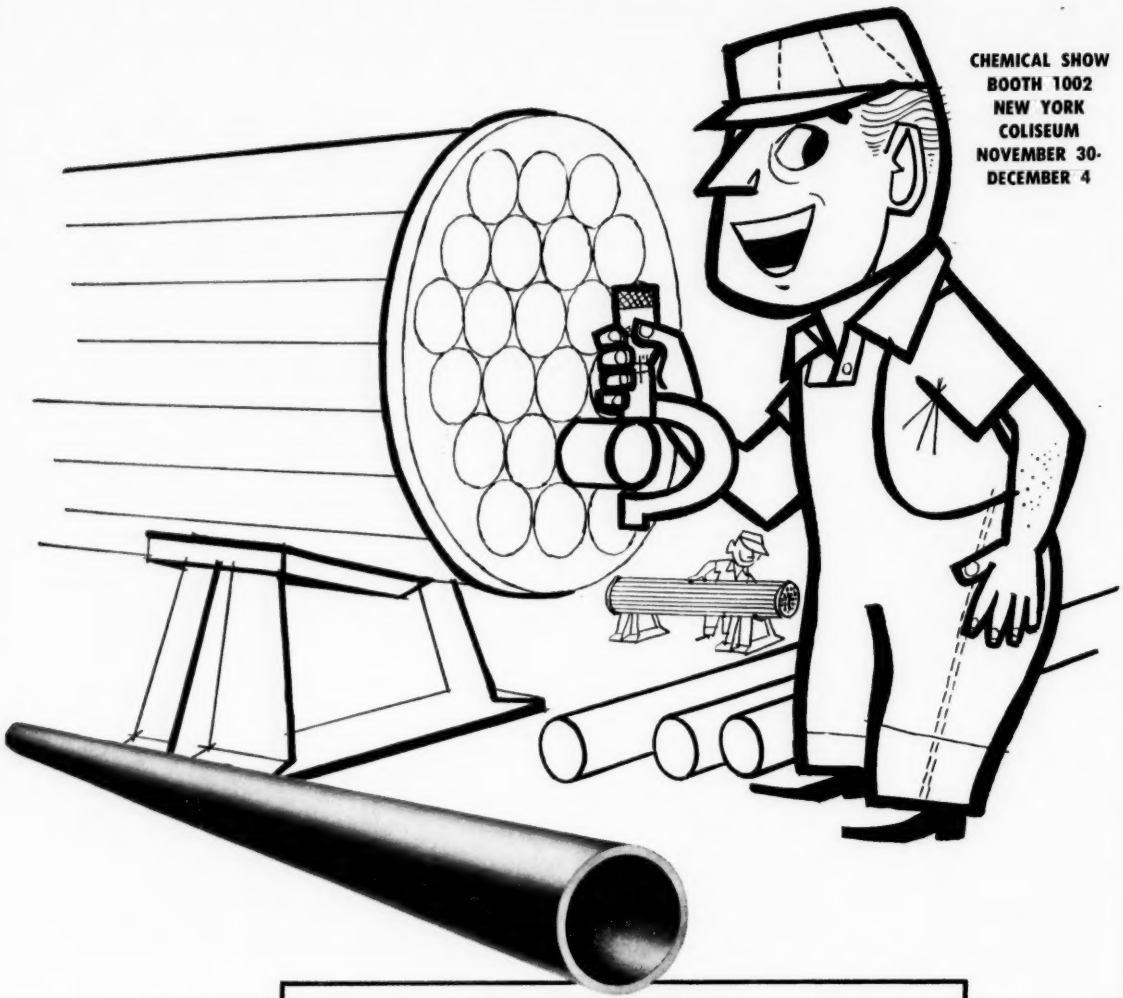
S are pulverize n a crushing machine and
the quench tar o kill the initial reaction.



AMIDATION REACTOR condenses the disulfonyl chloride ring to form crude chlorothiazide Reactor is glass-lined and is equipped with glass pipe fittings.



CENTRIFUGE separates the crude chlorothiazide crystals from the reaction liquor, after which crystals are dissolved and recrystallized to give pure Diuril.



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- . . . a complete range of tube sizes, for any type of heat exchanger

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For complete information about B&W Job-Matched Heat-Exchanger Tubes call the local B&W District Sales Office or write for Bulletin TB-329. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pennsylvania.

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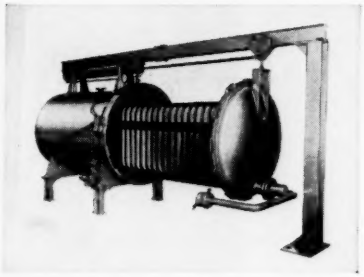
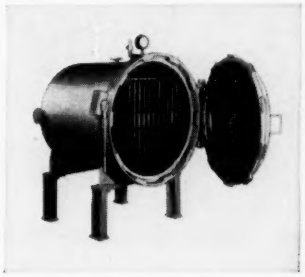


MODEL H units to 2000 sq. ft. provide capacities for large processing plants.



MODEL HB units to 400 sq. ft. meet most batch recovery needs.

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RECOVERY
TREATMENT
POLISHING
SEPARATION
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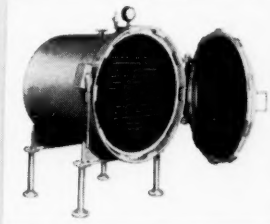
DISPOSAL

MODEL HL

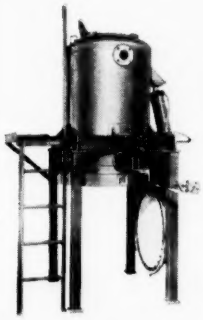
Available in units to 200 sq. ft. of filter area, the HL models offer advantages in cost reductions thru time and labor savings heretofore not available with horizontal leaf designs.



A 40 sq. ft. Model HL is capable of doing a job in less time than most filters double its size. One-man cleanout access speeds residue removal for added time savings and attendant operating economy.

MODEL HL FEATURES

- 4 to 15 minutes, one-man cleanout.
- Availability with choice of several filter media.
- Application-engineered variables to meet requirements.



EASY-ACCESS VERTICAL TYPES CONSERVE SPACE

Compact design coupled with thrifty filter leaf arrangement for continuous filtration provides units of desired capacity occupying a minimum of floor space. Convenient pipe connections make installation quick and easy.

MODEL VB units to 600 sq. ft. include bottom drop feature for heavy cake unloading.

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Process-Bowser makes available pilot plant test filters which determine answers to new or unusual filtration problems.

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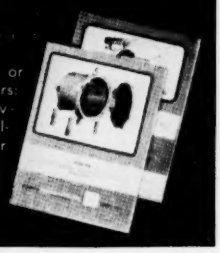

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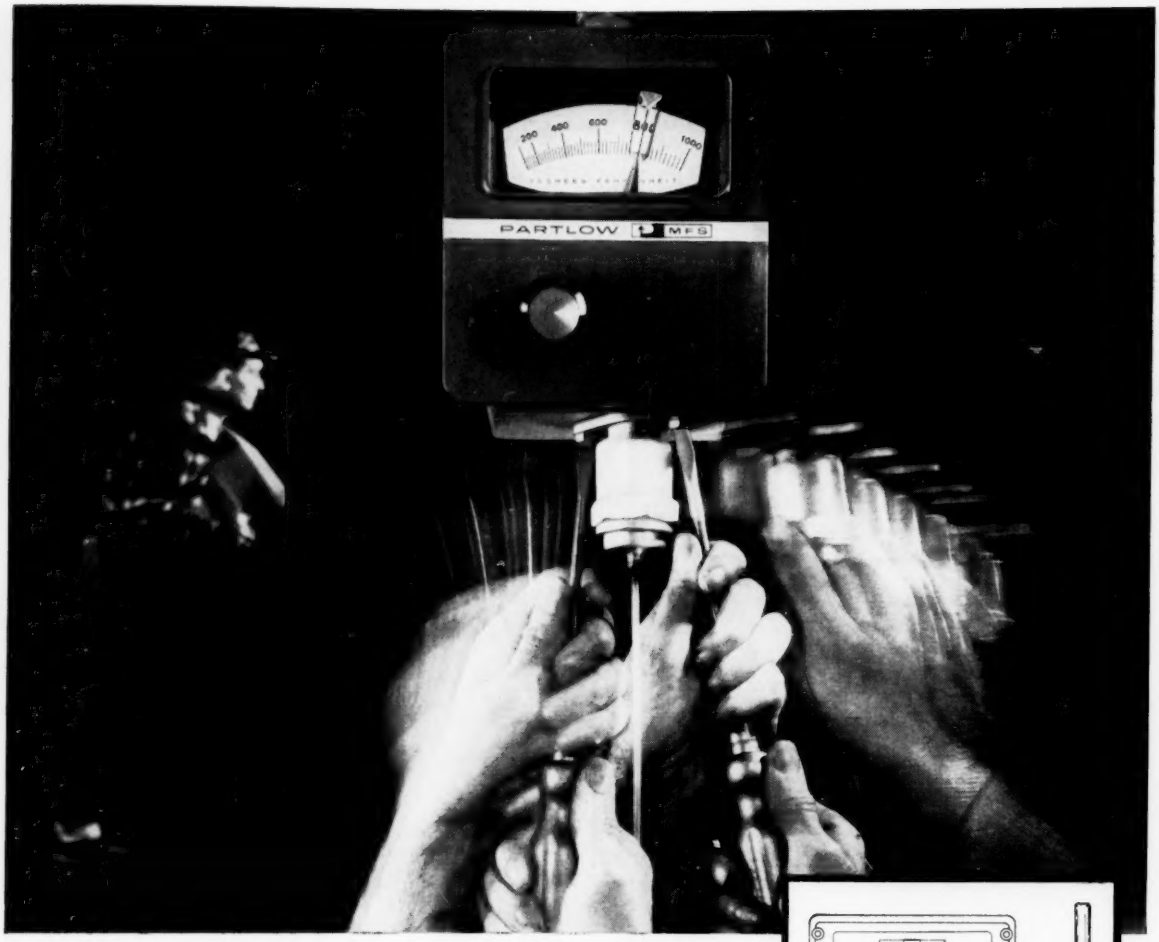


The Temperature Control Designed for Fast

"DO IT YOURSELF" MAINTENANCE

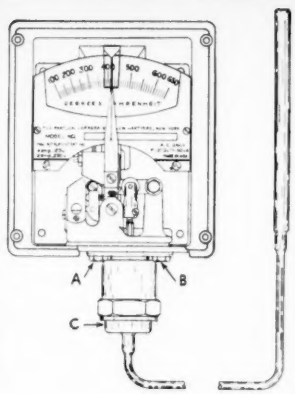
Right on the Job!

Rugged simplicity of design—along with the direct, positive power of mercury-actuation — combine to give Partlow maintenance and performance advantages no other type of temperature control can hope to equal.

Simplicity in the Partlow, for one thing, means that the control element can be changed *at the job site* in a matter of minutes with no other tool than a screwdriver . . . "Down time" is cut to an absolute minimum!

And simplicity in the Partlow also means the complete elimination of fussy electronic gadgets, delicate levers, hairsprings and other accessories that have a tendency to break down at the first trace of jar or jostle. Partlow controls are famous for their unfailingly accurate performance even under the most adverse operating conditions.

If you use or manufacture process equipment within the –30° to 1100° F. range, there's a Partlow pneumatic, electric or self-contained gas control (recording, indicating or non-indicating), to fit your application *precisely*. For details, write The Partlow Corp., New Hartford, New York. Dept. E-119.



Diagrammatic view of the new MFS reveals "quick-change" feature common to all Partlow controls. In case of damage, merely unscrew at points (A) and (B), and remove element (C) from case. Reverse this process, and your Partlow is ready to resume operation.

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TEMPERATURE CONTROLS

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The job: Produce five spherical reactors—Catalytic Reforming Units—to convert low octane gasolines to higher octane motor fuels.

The job site: Esso Standard Oil Company's new Powerforming Unit at Baton Rouge, Louisiana.

The job-team: Esso Research and Engineering Company prepared the basic design. Bechtel Corporation, San Francisco, developed the basic requirements and designed the various details. Wyatt Metal & Boiler Works, Inc., produced the shop drawings and fabricated the units in their Houston shops.

CF&I's Claymont, Delaware plant produced the alloy steel plates . . . for the shells and for manheads and nozzle connections.

The specifications: The CF&I-Claymont Alloy Steel Plates were manufactured to ASTM Specifications for Carbon-Molybdenum and Chrome-Molybdenum Steel . . . designed for high pressure and high temperature applications, with increased tensile and creep strength provided in accordance with varying safety factor requirements.

Minimum plate thickness—1⅞ inches.
I.D. of reactors—17 feet 1½ inches.
Net weight of each shell, without internal insulation—95,000 pounds.

The result: Another job well done through co-operative effort.

The CF&I-Claymont plant is equipped and ready to work with *you* by producing plate for any job, to any specification . . . in carbon, alloy or stainless-clad steels . . . in the dimensions, gage and shape of your choice. What's more, Claymont's completely-equipped Fabrications Shop turns out partially or full-fabricated steel plate components (for machinery or structural applications) in accordance with user requirements . . . in small or large-quantity lots.

Get complete information and prompt service through the CF&I sales office nearest you.

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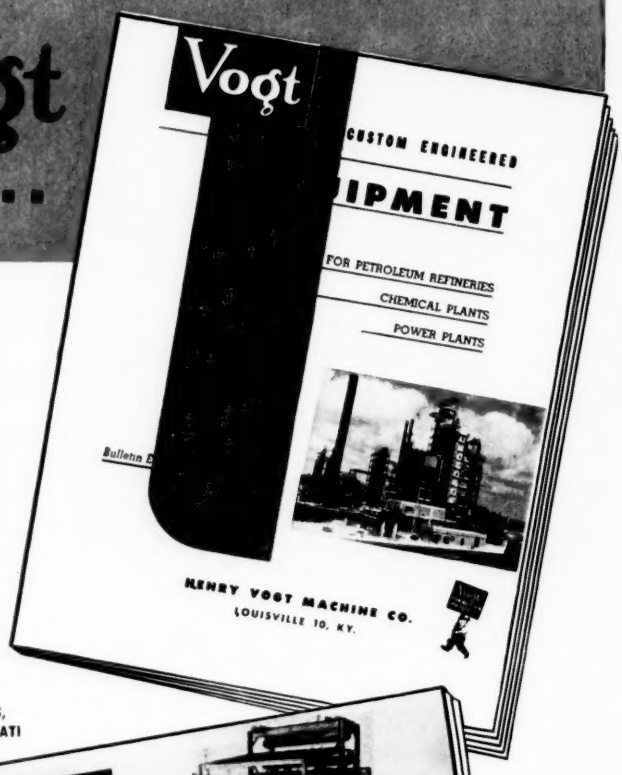

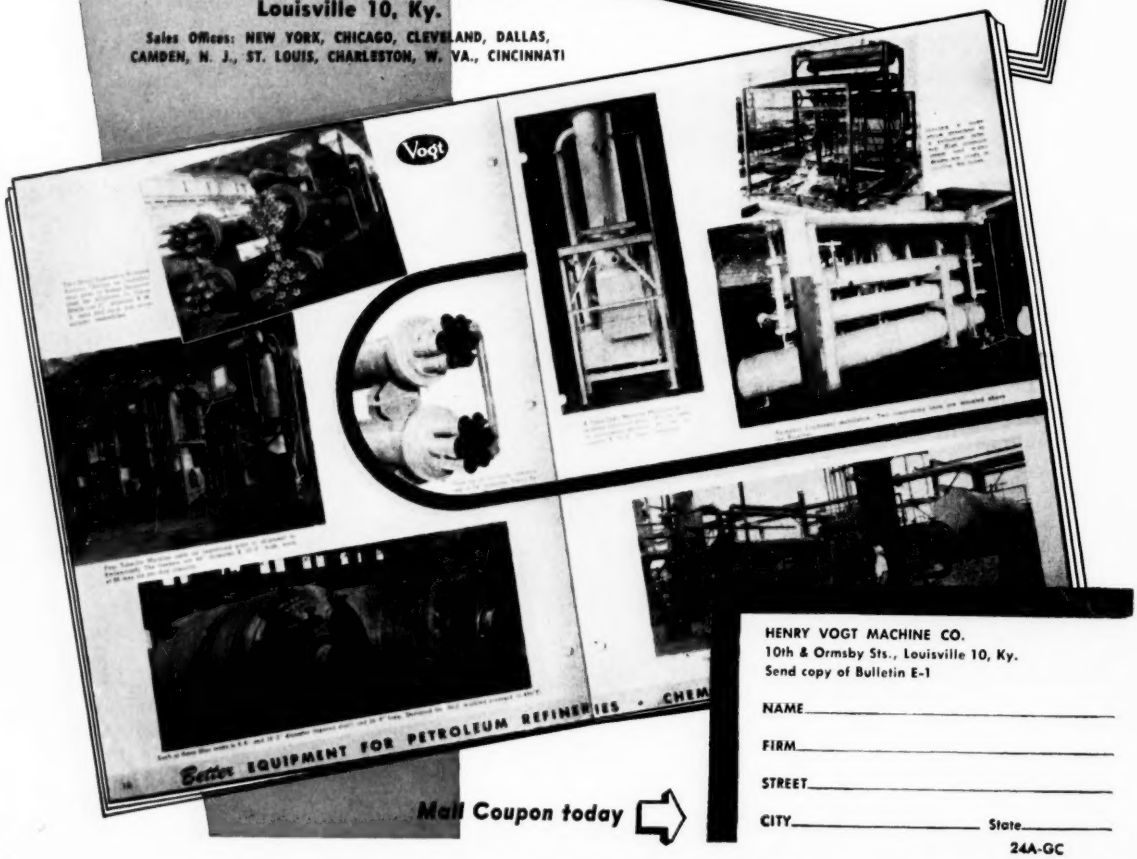

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Chemical Engineering
NOVEMBER 2, 1959

New Combinations of Liquid H_2 Liquid O_2 Fluorine Ozone Ready for Rockets

Cryogenic fuels are now operational. They can be produced in quantity; handled, transported, stored safely.

RAYMOND F. FREMED, Associate Editor

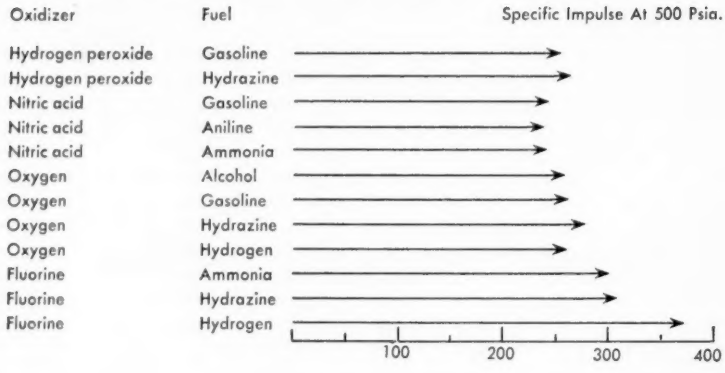
THIS WEEK the Ohio State University Press will publish the proceedings of a meeting which proved that chemical engineers can turn science fiction into fact.

On the student-deserted OSU campus this past midsummer, members of the propellants and combustion section of the American Rocket Society gathered to discuss, among other things, new developments in the handling of liquid rocket propellants.

Many of the breakthroughs announced were the result of work performed by chemical engineers; or by chemical engineers teamed with chemists and/or mechanical engineers. Major accomplishments include the following:

Liquid Hydrogen—Now it's available commercially on a sustained and economic basis. In case of a large spill of liquid hydrogen during handling, storage or transport, methods are available to minimize the hazard. Liquid-hydrogen-fueled aircraft engines are out of

Specific Impulse Determines Rocket Velocity and Range



the laboratory. They're already in the field on full-scale operations. Such an engine might be used for a high-energy, upper-stage rocket. Testing of these engines has involved the handling of millions of gallons of liquid hydrogen. And it's been done safely.

Fluorine — Safe transportation, transfer and storage of large quantities of liquid fluorine is a commercial reality today. Satisfactory materials of construction for containing the fluorine are available. While there is still some doubt about safe toxicological limits for the combustion products of a fluorine-fueled rocket, there is little doubt that a liquid-fluorine rocket engine should now be practical, providing there is an important enough mission for one.

Ozone in Oxygen—Ozone is a high explosive which is easily detonated. One way to make it safer to handle is to mix it with liquid oxygen. Although experimental fueling systems at Lewis Research Center have been destroyed several times by this dangerous combination, a safe rocket-fuel oxidizer might be 30% ozone dissolved in liquid oxygen.

Other Fuels—In the never-ending search for better fuels and higher specific impulse, the Advanced Research Projects Agency is spending large sums of money on research in basic chemistry and chemical engineering. Among the contractors are Dow Chemical Co., Esso, American Cyanamid and Minnesota Mining & Manufacturing Co.

Because the preliminary program announcement indicated that the meeting would be of more than usual interest, *Chemical Engineering* decided to cover the sessions.

CE Covers for You

I arrived in Columbus on a hot Monday morning, checked in at the OSU Student Union and placed myself in the competent care of the engineers from North American Aviation Co. (Port Columbus, Ohio) who manned the publicity committee. Since the only other members of the technical press in evidence were Mike Yaffee of *Aviation Week* and John Newbauer of *Astronautics*, what follows is a somewhat exclusive report on some of the technical sessions.

Proceedings of the entire Propellant Thermodynamics and Handling Conference will be available starting Nov. 1 from the Ohio State University Publications Office, Engineering Experiment Station, Columbus 10, Ohio, at a cost of $2.50 for single copies.

Now, Cryogen Hydrogen

The first plant for continuous production of liquid hydrogen was designed, constructed and operated by Air Products, Inc., of Allentown, Pa. The plant is in Painesville, Ohio. It is of moderate capacity and was put into operation during the summer of 1957. Much of the basic data came from experimental work performed by the National Bureau of Standards in Boulder, Colo. (See *Chem. Eng.*, Nov. 1953, p. 134.)

A plant of similar capacity has been put in operation by the Stearns-Roger Mfg. Co. of Denver at Bakersfield, Calif. This was during the winter of 1957-1958.

Hydrogen availability moved from lb./day to tons/day when the Air Force asked Air Products to furnish a plant in the West Palm Beach, Fla., area. This plant went into operation early this year.

The hydrogen production section combines crude oil, oxygen and water to generate hydrogen gas via the Texaco partial-oxidation process. Lummus designed, engineered and constructed the hydrogen production section of the plant. They report that a better than 99%-pure hydrogen gas stream is being produced.

Air-separation processes supply the oxygen used for partial oxidation and the liquid nitrogen required for liquefaction of the hydrogen. Refrigeration for the hydrogen liquefier is obtained in a number of ways including: streams of cold nitrogen gas; liquid nitrogen; reciprocating and turbo expanders; and at lower temperature levels, from special turbo expanders designed for the first time to operate on hydrogen.

First talk on the program at Columbus was delivered by P. C. Vander Arend of Air Products who provided a description of this Florida facility.

According to Vander Arend, the storage system of the plant consists of a number of 28,000-gal. tanks (see photo) which are located some distance from the liquefier. Pipelines connect the storage system to the plant, allowing boiled-off liquid to return as vapor from the tanks to the plant for reliquefaction. Vacuum insulation is used on the pipelines.

To minimize losses, liquid transfer pumps are recommended for hydrogen service.

In addition to storage tanks, a number of vacuum-insulated trailers are available, making it possible to transport liquid hydrogen from the plant area to other locations where it is used.

Trailers in use at the present time have a capacity of approximately 6,000 gal. During a highway transport of 24 hr. some of them show a pressure rise of only 3 psig. on the hydrogen tank. However, considerable improvement in insulation can be made and before long Air Products hopes to have some trailers in service with a capacity of better than 7,000 gal.;

and a pressure build-up of not more than 1-2 psig./day during over-the-road transport.

Concluding his talk, Vander Arend predicted that the 70% on-stream time of the Florida plant can be increased; and by better monitoring of and accounting for losses, they will be cut to less than 10% of full capacity. In any future plants that may be built, even better performance can be expected.

What If It Spills?

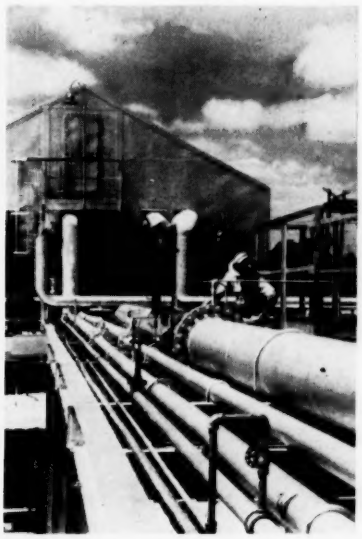
One of the matters of concern in the handling of any dangerous material is the problem of handling and decontaminating an unintentional leak or spill. Chemical engineers of Arthur D. Little, Inc., have been studying the "Safety Aspects in Handling and Storage of Liquid Hydrogen" at an isolated area on Cape Cod in Massachusetts.

A. D. Little has considered this problem: There has been a military specification that 800 ft. is the minimum distance to be used between liquid-hydrogen production units and storage tanks. Is this a safe distance?

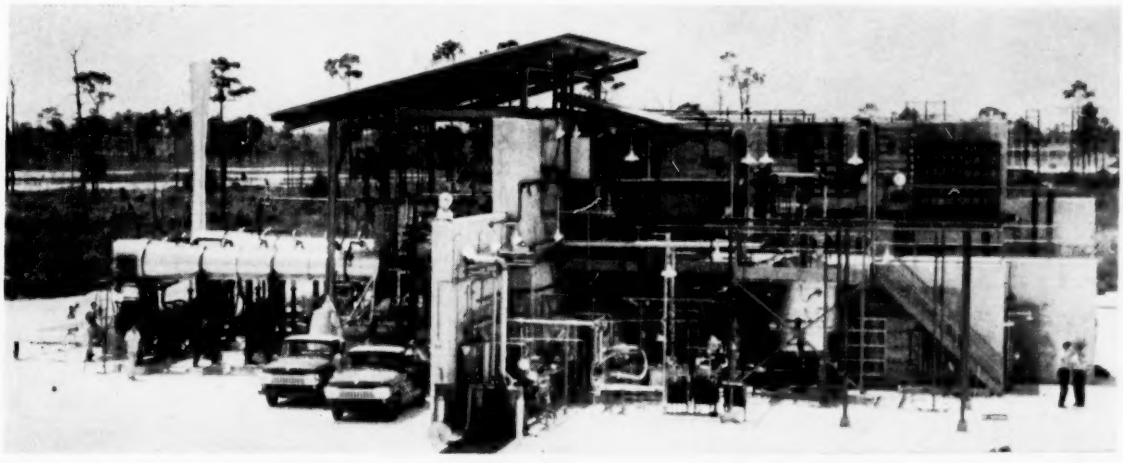
A possible accident situation might arise when a 60,000-lb.-capacity storage tank collapses and you get a reaction between the spilled hydrogen and the atmosphere. When mixed with air this

Air Products' large-scale production and storage of liquid hydrogen . . .

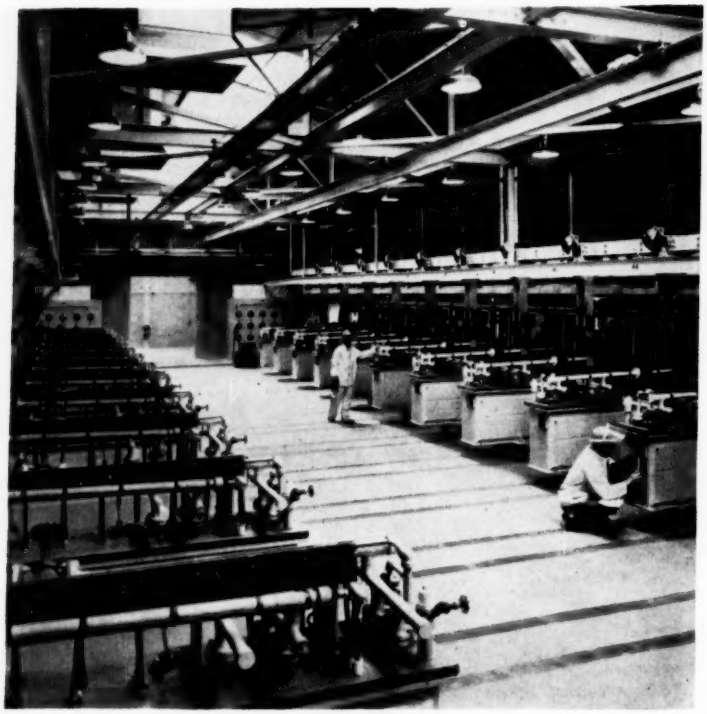
delivered by pipeline . . .



. . . to Pratt & Whitney's rocket-engine test stands deep in the Everglades of Florida.



Allied Chemical generates fluorine in these electrolytic cells.



Liquid nitrogen liquefies fluorine and chills it to below —306 F.

would add up to 2,000,000 lb. of reacting gases.

Another possible accident condition would be the accumulation of oxygen in a tank or production unit because of a leak, leading to a blanket of "solid air" over the hydrogen. This could lead to an explosion. Another possibility might be the impact of some hot metal fragments on equipment containing liquid hydrogen.

Tests were set up to study these possibilities. In every case the hydrogen would not detonate unless a deliberate shock wave was used to initiate the detonation. A. D. Little used No. 6 blasting caps to do the job. If a spark was used instead, there was a fire, no explosion.

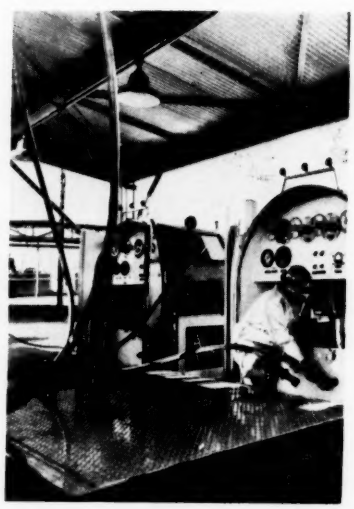
Hydrogen flames are not too sensitive to the wind. They are colorless and invisible and even a 25-30-mph. wind doesn't deflect the straight-up nature of the flames. Therefore the main problem in the spill situation for liquid hydrogen would be thermal effects rather than the detonation possibility.

A. D. Little's conclusion: Current Air Force regulations may be more conservative than necessary; a quantity-distance formula would be more useful.

Hydrogen as a Fuel

Pratt & Whitney's (Div. of United Aircraft Corp.) Florida re-

Trailer trucks load here . . .



search and development center near West Palm Beach has been investigating the combustion characteristics and performance of hydrogen with various oxidizers since early in 1955.

The feasibility of handling and using hydrogen in aircraft and for fueling rocket engines has been demonstrated. C. D. Robin, chief of experimental test operations engineering for Pratt & Whitney in Florida spoke about their "Experience With Handling Liquid Hydrogen in Engine Testing."

A vacuum-insulated feed line connects the Air Products liquid-hydrogen production plant to the Pratt & Whitney engine-test stands. The line is over 2,000-ft. long and is capable of transferring 400 gpm. About 50,000 gal. of hydrogen is commonly pumped in a single test. For this special service, Pratt & Whitney has designed and developed liquid-hydrogen pumps capable of supplying over 700 gpm. at 1,000-psi. pressure drops.

Valves in cryogenic pipelines should have their stems and housings arranged so that the valve packing is kept away from the cold line. Vacuum jacketing must be used around the valves too. Valve seats should be fabricated from Teflon or Kel-F.

Any tee in the pipeline is a problem. If the tee is vertical the hydrogen will boil off. Purge the lines with nitrogen, and you can leave the line in a safe condition. But don't allow any hydrogen-containing line to get below atmospheric pressure.

There should be no possibility of any air getting into hydrogen lines. Instrument lines are particularly bad because they are dead-ended sections.

For the engine test stands, a variety of special equipment has been designed (see photo on p. 71). After use in the engines, hydrogen gas or liquid mixed with combustion products must be led to a flare to be disposed of by burning. At first this was thought to be a difficult engineering problem.

Now, simple vertical flares can be used to dispose of liquid fuel with no difficulty. Spills are not dangerous as long as there is no source of ignition. A spill of a few gallons will evaporate immediately. However, when hundreds of gallons are spilled, the ground freezes, the air liquefies and a cloud of ice crystals and water vapor forms. The cloud is a good indication of where the hydrogen is going.

In conclusion, Robin stated, "Our experience has been that a hydrogen fire does very little damage to a properly designed test stand and burns out quickly; we have found that in many ways liquid hydrogen is less dangerous than gasoline because a leak does not accumulate on the ground or soak into other materials."

Ferocious Fluorine Tamed

Next on the program were sessions developed by Hans R. Neumark, General Chemical Division of Allied Chemical and Edmund R. Jonash, Lewis Research Center, National Aeronautics & Space Administration, Cleveland.

Into the center ring of the arena they led the wild beast fluorine; and they made it sit up and jump through hoops as the crowd gasped.

J. M. Siegmund (Allied Chemical), a chemical engineering graduate of the Newark College of Engineering, led the parade with a discussion of "The Transportation, Transfer and Storage of Liquid Fluorine."

Under the sponsorship of the U. S. Air Force at Wright Field, Dayton, Allied has been studying fluorine as a possible rocket fuel oxidizer. Fluorine's normal boiling point is −306 F., so liquid nitrogen jackets at −320 F. are used to surround fluorine containers. Outside of this a vacuum-insulated jacket is used. (Further details are given in *Chem. Eng.*, Sept. 21, 1959, p. 78.)

In such a container, liquid fluorine can be stored for 15 to 25 days with a product loss of less than 0.75% of the total volume/day. Materials of construction should be

. . . and then go cross-country delivering fluorine to rocket test stations in isolated areas.

Monel, stainless steel, nickel or aluminum. Since 304 stainless has good cryogenic properties (see *Chem. Eng.*, Oct. 5, 1959, p. 174) it is an all-around choice for general service at low temperatures. However, all contact with fluorine is against Monel surfaces.

Valves have copper seats and Monel bellows. Packing is the chevron type cut from Teflon.

The storage containers now in use have shown very satisfactory staying times. At General Chemical's development laboratories in Baton Rouge, 5,000-lb. storage units have displayed staying times of up to 25 days. In fact, because of the unique design, if the liquid nitrogen refrigeration should be lost, the fluorine would be retained in the liquid state for at least 24 hr. and the pressure within the tank will not rise to the allowable working pressure for several days.

First bulk shipment of liquid fluorine was by trailer truck from Baton Rouge, La., to rocket test stations on the West Coast in Aug. 1956. The quantity was 1,200 lb.

Now shipments are being made by tank trucks to all parts of the country. As much as 5,000 lb. of liquid fluorine can be shipped on a single truck. The ICC has issued a special permit to General Chemical covering these shipments. If required, shipment can be made by railroad tankcars filled with 25 tons of liquid fluorine. That's 50,000 lb. of the stuff at one time.

Cleanliness Is Next to

Fred Fink of Battelle Memorial Institute in Columbus, took the microphone next and told us about "Materials of Construction for Handling Fuorine," at various temperatures.

According to Fink, stainless steel doesn't have much advantage over carbon steels. Copper is satisfactory up to 700 F. Magnesium and aluminum alloys seem to be rather good to 900 F. in some cases. Nickel alloys are usable up to 1,200 F.

Monel has the advantage that it is resistant to hydrofluoric acid as well as to liquid fluorine. Inconel is not as good as Monel and nickel. Titanium is only good up to 300 F. However, if titanium were anodized to give a TiO_2 coating, the useful range would be extended, perhaps.

Tin is unsatisfactory in fluorine or HF service, although tin gaskets can sometimes be used in liquid fluorine lines. Platinum, palladium and uranium are all attacked by fluorine. Glass is good to 300 F.; borosilicate type glass to 400 F.; and quartz to 500 F. Graphite is unsatisfactory.

Of the organic materials, Teflon is satisfactory up to 390 F. But it must be scrupulously clean.

And this was probably the most significant point of the presentation: Any trace of grease or dirt in a fluorine line or vessel may result in the generation of a hot spot. Therefore, cleanliness is next to sanity in handling fluorine.

Hold Your Breath and Run

One of the more vigorous presentations—from the audience interrogation point of view—was that made by E. J. Sargent of Reynolds Metals on the "Toxicity of Fluorine and Hydrogen Fluoride."

Fluorides have been studied for many years because of their known toxological properties. The Public Health Service of the U. S. uses an allowable threshold limit of 3 ppm. for hydrogen fluoride and 0.1 ppm. for fluorine.

Based on his tests with various animals, Dr. Sargent suggests that these limits may be rather stern and that considerable further study is required in this particular field.

He commented on the possibility of humans being suffocated by remaining in an area with a high concentration of fluorine or hydrogen fluoride fumes. From personal experience in such a situation, he reports that human beings will not voluntarily remain in any such area. The fumes are so obnoxious that they will run from the area before the threshold concentration is reached. However, if they can't escape, they will suffocate.

If Fluorine Spills

James Rollbuhler of Lewis Research Center—a chemical engineering graduate of MIT, by the way—was next man up and he reported on what happens when you intentionally spill large quantities of fluorine.

Best over-all cure seems to be a deluge of water and soda ash. This works well with liquid fluorine, but not so well with gaseous fluorine. Net result is a dilute HF fog.

John Siegmund of Allied came back for an encore performance showing excellent color films of the decontamination of fluorine spills. Even more spectacular were films from Edwards Air Force Base, Calif., showing the decontamination of large-scale spills of liquid fluorine.

At Edwards, they have deliberately set off a spill of 1,600 lb. of fluorine. Deluging it with 16,000 lb. of soda ash and lots of water seems to handle the job reasonably well.

Ozone in Oxygen

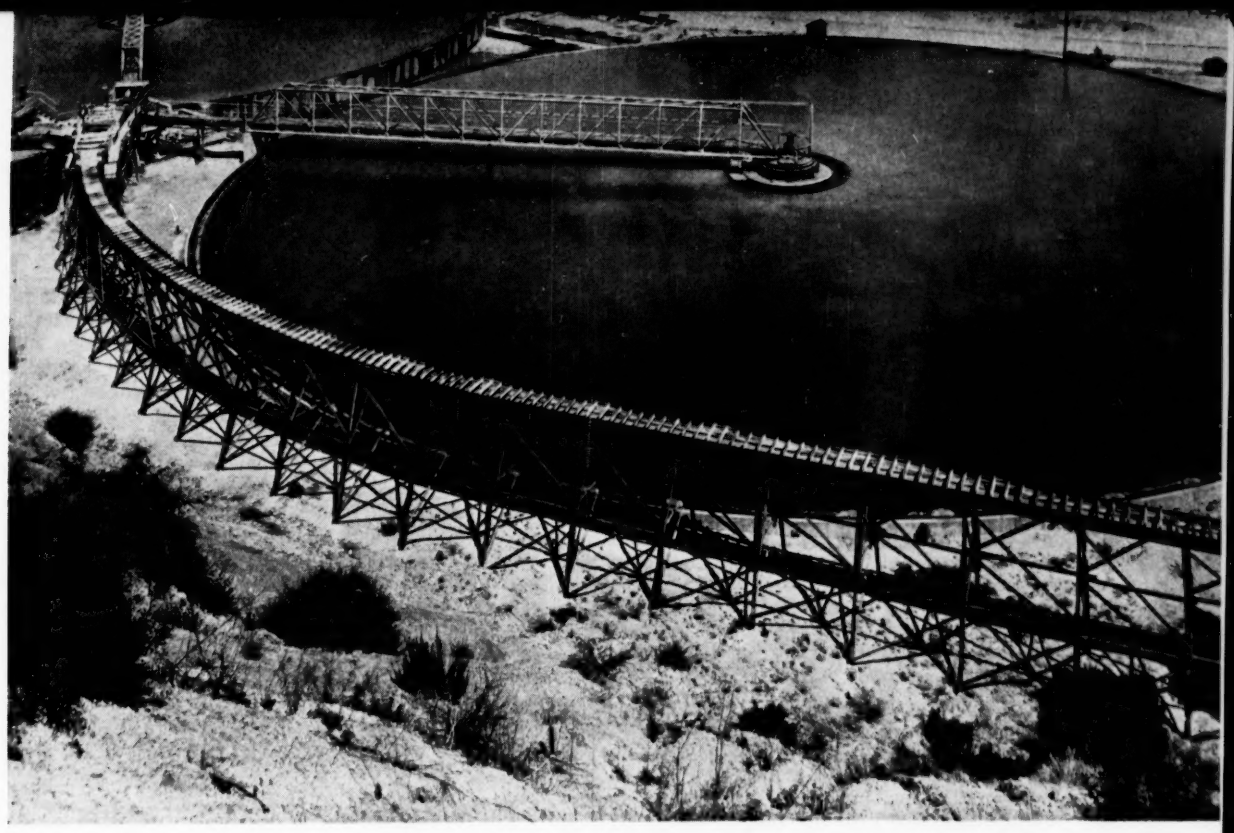
Chemist Riley O. Miller of Lewis Research Center suggested an interesting possibility for further investigation. Ozone can be used dissolved in liquid oxygen as a high-energy oxidizing agent.

He described small-scale tests on such a system. Because of the phase rule, increasing the concentration of ozone can lead to a separation into two phases, one of which is above the safe-concentration limit for ozone.

However, by careful handling a 30% ozone concentration might be very useful.

Next year, or in 1961, the American Rocket Society is thinking about a meeting on storable propellants. Chemical engineers will be looking forward to it.

RAY FREMED, associate editor in our engineering practice group, is a member of the American Rocket Society, the Combustion Institute, API, ASEE and AIChE. In AIChE he's both a national and local officer, currently serving as Secretary-Treasurer of the Heat Transfer Div. and Treasurer of the New York Section. His academic degrees are B. Ch. E. and M. Ch. E. In addition to articles and feature reports, he also edits the popular *You & Your Job* department of *Chemical Engineering*.



CE Refresher

Review Sedimentation Theory

When handling thin or thick pulps, correlate laboratory tests and empirical relations to get practical design of operating settlers.

A. A. ANDERSON and J. E. SPARKMAN, Kaiser Aluminum & Chemical Corp., Baton Rouge, La.

FROM a theoretical standpoint, sedimentation as used in the chemical and especially the metallurgical industries is still poorly understood as a unit operation. Nevertheless, methods have been developed by which reasonably accurate equipment design can be achieved.

Mixtures of finely divided solids and liquid processed in commercial sedimentation equipment may be either crystalline or slimy in nature and are called pulps. However, all possess a common characteristic. Because of some property, usually a fine particle size, separation of the solid phase from the liquid cannot be as economically accomplished by other methods such as filtration.

These pulps may also be divided into two classes, thin or thick, depending on the concentration of the solid phase. Thin pulps are those whose concentration of solids is low. In these pulps, each particle settles more or less by itself without undue interference from its neighbors. In batch settling, the solid-liquid interface builds up from the bottom of the container.

In thick pulps, each particle is greatly hindered by its neighbors because of the high concentration. In batch settling tests, the thick pulp forms a sharp solids-liquid interface at the surface which gradually subsides. Change from one type of pulp to another occurs gradually at a concentration of 1 to 2% by weight.

How to Explain Thin Pulp Separations

First, consider the mechanism by which a solid particle settles in a liquid. For theoretical analysis, as-

Arvid A. Anderson

James E. Sparkman

Our regular CE Refresher authors, Jesse Coates and B. S. Pressburg have invited A. A. Anderson and J. E. Sparkman as guest authors of this installment of the series

ARVID A. ANDERSON is staff chemical engineer in the development department at Kaiser Aluminum. He has been with Kaiser since 1949 and has previous experience with Shell Development Co. and the California Research Corp.

Mr. Anderson is chairman of the Baton Rouge section of ACS and is a Professional Engineer in California. He holds the B. S. and M. S. degrees in chemical engineering from the Univ. of Washington.

JAMES E. SPARKMAN joined Kaiser Aluminum in 1957 and is now chemical engineering supervisor of their production control department. Previously, he served a two-year stint as instructor at Louisiana State University.

Mr. Sparkman is a Professional Engineer in Louisiana and has the B. S. and M. S. degrees in chemical engineering from Louisiana Tech. and L. S. U. respectively.

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sume that the particle is freely moving. For this condition, other particles are absent or, if present, do not affect the motion of the particle under consideration.

A solid particle in a liquid-solid suspension tends to settle if its density is greater than that of the suspending medium. Settling occurs because of the gravitational force acting on the particle. This force which causes the particle to settle will be opposed by two additional forces:[1]

• Buoyancy effect results from displacement of the liquid by the particle.

• Frictional resistance from relative motion of the particle and the fluid.

Therefore, the rate at which the particle settles is dependent on the variables that determine the relative magnitude of each of these forces. For a given particle the frictional forces resisting settling increase with velocity. Frictional resistance increases as a particle begins to accelerate. Finally, a velocity will be reached at which the frictional forces are equal to the gravitational forces. After this point is reached, the velocity of the settling particle becomes constant. This final, maximum velocity is dependent on size, shape and density of the particle as well as the density and viscosity of the fluid.

For simplicity in studying the relationship of these variables, the assumption is usually made that the solid particle is spherical and settling in an incompressible liquid under the force of a uniform gravitational field.

Dimensional analysis may be used to solve for the relationship[11] between the variables involved in settling mechanism. Frictional resistance F_R of liquid to the passage of a solid sphere is a functional of four independent variables: viscosity and density of the liquid, and the diameter and velocity of the particle. Note this does not include the resistance due to buoyancy.

By using dimensional analysis, the following empirical equation may be obtained:

$$F_R = k\, d^2 v^2 \rho_L (dv\rho_L/\mu)^{-z} \qquad (1)$$

The factor $F_R/kd^2v^2\rho_L$ is a function of the Reynolds number of the settling particle and is commonly called the drag coefficient C_D.

The force tending to cause the particle to settle is the difference between the weight of the particle and the weight of the displaced liquid. Once the terminal settling velocity has been reached, this accelerating force F_A must be equal to the resisting force F_R.

$$F_R = F_A = (\pi\, d^3 g)(\rho_s - \rho_L)/6 \qquad (2)$$

Substituting Eq. (2) into Eq. (1) yields:

$$C_D = \frac{\pi\, dg}{6kv^2}\left(\frac{\rho_s - \rho_L}{\rho_L}\right) \qquad (3)$$

Nomenclature

A	Settler area, sq. ft.
A_u	Unit settler area, continuous operation and for capacity of one ton dry mud solids, sq. ft/(ton) (24 hr.).
C_D	Drag coefficient.
d	Particle diameter.
D_w	Weight ratio, lb. slurry or liquor/lb. dry mud solids in underflow.
D_v	Volumetric ratio, ml. slurry or liquor/gram dry mud solids in underflow.
E	Equilibrium mud level to which mud tends to settle in compression zone, $dH/dt = K(H - E)$.
F_w	Weight ratio, lb. slurry or liquor/lb. dry mud solids at any concentration between the feed and the underflow.
F_v	Volumetric ratio, ml. of slurry or liquor/gram dry mud solids at any concentration between the feed and the underflow.
F_A	Force tending to accelerate settling particle.
F_R	Frictional force resisting particle settling.
g	Gravitational acceleration.
G	Specific gravity of solids in pulp.
H	Height of liquor or mud solids interface in test cylinder reading from bottom to top, ml.
k	Constant in Eq. (1).
K	Constant in Eq. (10), hr.$^{-1}$
N	Weight of dry mud solids in graduate, gram.
N_{Re}	Reynolds number of settling particle.
R	Settling rate, ft./hr.
S	Average specific gravity of pulp in compression zone.
$Sp.Gr.$	Specific gravity of clear liquid.
t	Time.
u	Viscosity of clear liquid.
v	Velocity at which particle settles.
v_m	Terminal settling velocity.
V_u	Unit volume required for thickening per ton of solids, cu. ft./(ton) (24 hr.).
z	Exponent.
ρ_L	Density of clear liquid.
ρ_s	Density of solid particle.

Newton[12] developed an expression for F_R:

$$F_R = \frac{C_D A \rho_L v^2}{2} = \frac{C_D \pi d^2 \rho_L v^2}{8} \quad (4)$$

Rearranging Eq. (4) and using the value of F_R from Eq. (1) gives:

$$C_D = \frac{4\,dg}{3v^2}\left(\frac{\rho_s - \rho_L}{\rho_L}\right) \quad (5)$$

Hence, the terminal settling velocity v_m is:

$$v_m = \left[\frac{4\,dg}{3C_D}\left(\frac{\rho_s - \rho_L}{\rho_L}\right)\right]^{0.5} \quad (6)$$

Eq. (6), often called Newton's law, expresses the terminal settling velocity in terms of the variable factor C_D.

To use Eq. (6), the value of C_D must be known. As previously shown, C_D is a function of the Reynolds number of the settling particle. Flow mechanism[9] around the settling particle can be laminar or turbulent. In the laminar region, viscous forces are predominant; in turbulent regions, inertial forces are more important. Therefore, the relationship between the coefficient C_D and the Reynolds number is dependent on the prevailing flow mechanism.

The work of Stokes[13] concerning the force resisting the motion of a spherical particle allowed the development of an expression for the terminal settling velocity of a particle in the laminar region. This expression is:

$$v_m = \frac{(\rho_s - \rho_L)gd^2}{18\mu} \quad (7)$$

This expression does not contain the variable coefficient C_D. However, the value of $(\rho_s - \rho_L)$ in Eq. (7) may be substituted in Eq. (6) to give an expression for C_D in the laminar region.

$$C_D = 24\left(\frac{\mu}{dv_m\rho_L}\right) = \frac{24}{N_{Re}} \quad (8)$$

In the laminar flow region, Eq. (8) may be used to evaluate the coefficient for spherical particles. Examination of Eq. (8) shows that the coefficient for a given particle in the laminar flow region may be conveniently plotted as a function of the Reynolds number. The coefficient would be represented by a straight line on logarithmic coordinates with a slope of minus one.

Experimental results show that this relationship exists up to a Reynolds number of approximately three to four for spherical particles. In this range of Reynolds numbers the slope of the relationship decreases with increasing Reynolds numbers up to value of approximately 1,000. For Reynolds numbers ranging from 1,000 to 250,000, the value of C_D is relatively constant and is independent of Reynolds number. Plots[1, 14] of C_D as function of Reynolds number for spherical and other specific shapes are available.

As indicated by Stokes relationship in Eq. (7) and also demonstrated by Camp[2, 3, 4] and Straub,[17] a particle settling under laminar flow conditions is resisted by a force proportional to the first power of the velocity. Particles settling under turbulent conditions are resisted by a force proportional to some power of the velocity greater than one.

All of the preceding equations are applicable only to free-settling spherical particles. A spherical shape offers the least resistance to particle flow through a liquid. Therefore, a spherical particle of any given material settles faster than the same material in any other shape. The particle always orients itself so as to offer the greatest resistance to settling. Specialized techniques[1] are available that allow the equation to be applied to nonspherical particles.

Thin Pulp Batch Test Gives Design Data

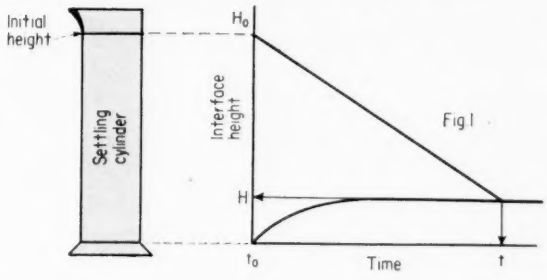


Fig. 1

Settler Design for Thin Pulps

Data for settler design with thin pulps are obtained by several methods. The batch settling test on a thin pulp results in a curve similar to Fig. 1. In such a batch test, the solids-fluid interface builds up from the bottom along with a gradual improvement in the clarity. At time t, it may be assumed that all particles of a size greater than that characterized by the settling rate $(H_o - H)/(t - t_o)$ will have already settled. If the turbidity of the supernatant liquor at this time is satisfactory, or if the feed solids suspension is known to contain a negligible quantity of fines smaller than the characterized size, batch settling data may be used for settler design.

Settling rate $(H_o - H)/(t - t_o)$ is converted into ft./hr. and substituted in the following equation:

$$A = \frac{\text{Overflow rate}}{\text{Settling rate}} \quad (9)$$

Where the overflow rate is equal to the feed rate minus the underflow rate and is expressed in cu. ft./hr. Note that the settling rate in Eq. (9) is that of the limiting fine particle size. The settling rate could also be computed by Eq. (7). In other words, a settler operating on thin pulps is functioning as a hydraulic classifier with all particles larger than a limiting size being found in the underflow.

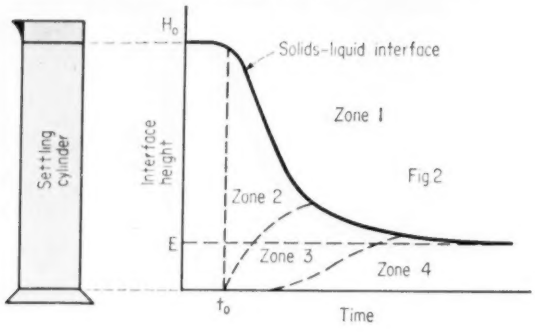
Because of short-circuiting, thermal currents and design elements which may interfere with the attainment of the desired flow patterns, the design area is usually made considerably larger than that predicted by Eq. (9). Safety factors of 100% or more are not uncommon.

Collectors and flocculating agents are useful adjuncts to assure clean overflows as well as reducing settler area requirements or increasing the capacities of existing units.

Eq. (9) suggests that the area requirement of a settler operating with thin pulps is the primary factor in producing overflow clarity and liquid depth is unimportant. In practice, depth is found to be of considerable importance. Increasing depth[7, 8] tends to improve liquor clarity.

The effect of increased liquor depth seems to mini-

Thick Pulp Test Yields Complex Results



mize short-circuiting of feed to overflow discharge and to increase retention time. Hence, we find improved flow patterns and increasing probability of flocculation of small particles which would normally be present in the overflow.

Laboratory data cannot accurately predict the effect of increased liquor depth. Judgment and experience are prerequisites for the attainment of satisfactory settler designs for operation on thin pulps.

Theory of Settling in Thick Pulps

In batch settling tests, a thick pulp is characterized by the development of a solids-liquor interface at the top of the settling graduate. After a brief flocculating period t_o which may or may not be present, a period of constant settling is observed, followed by a period of decreasing settling rate. The position of the solids-liquor interface is indicated in Fig. 2. This settling curve is divided into four parts or zones.

• Zone 1 is the clear liquor phase where true free-settling can occur according to the principles outlined earlier for single particles. Because of the filtering action of the larger particles, the more concentrated the initial suspension, the clearer will be the liquor in the upper zone. Additional settling and flocculation occur in this zone whose function in a commercial settler is to provide a clear overflow.

• Zone 2 is characterized by a constant rate of settling such that the action may be described by $-(dH/dt)$ equals a constant which is characteristic of the pulp.

This zone, sometimes erroneously referred to as the free settling zone, is more aptly termed the zone of collective subsidence. The larger particles serve to collect and strain out the finer particles. The concentration of solids is so large that each particle substantially retains its position with respect to all of its neighboring particles. Therefore, this zone has the concentration of the original slurry. In the zone of collective subsidence, the liquor is the continuous phase and the solids form the discrete phase.

• Zone 3 is termed in this article the compression zone. The concept of what constitutes the compression zone varies among different authors and care is required in reading their articles to determine what is meant.

In our article, the compression zone refers to the first portion of the decreasing settling rate period. The solid particles retain their relative horizontal positions but the vertical positions compress. The main resistance to settling is that offered to the flow of liquor through a network of capillaries to the solid-liquid interface. Because of the presence of these capillaries, the liquor is considered a discrete phase. The mud may be considered to be the continuous phase.

The differential equation describing the settling curve in this zone is:

$$-\frac{dH}{dt} = k(H - E) \qquad (10)$$

Here the mud-liquor interface tends to approach an equilibrium level in the settling graduate. The compression zone is often the limiting area requirement in the design of settlers, but Zone 2 may be limiting in some situations.

• Zone 4 may be called the compaction zone. This zone is reached when the capillary liquid has been forced from the mud and occurs when the mud-liquor interface has subsided below the value of E shown in Fig. 2.

Available capillary channels for liquor flow have disappeared and the mud becomes the complete phase. The deliquoring and, therefore, the settling rate of this zone is probably governed by diffusion. The settling rate in this zone is usually so slow that this zone is of minor commercial importance.

What Zones Occur in an Operating Settler

Location of the different zones in a settler operating with high solids concentration in the feed is shown in Fig. 3. The volume of the vessel is predominantly taken up by clear liquor (Zone 1) and by the compression zone (Zone 3). Normally, a zone corresponding to the feed concentration (Zone 2) will either be quite thin or not detectable. Existence and depth of the compaction zone (Zone 4) is primarily dependent on the characteristics of the solids and to some extent on operating modes and vessel design.

In most commercial settling vessels, rakes are provided to assist in the movement of the settled mud solids from the periphery of the vessel to the center for discharge. Rake action is of no importance in settling Zones 1 and 2, but is important in Zones 3 and 4. For this reason, rakes or small agitators rotating from one to several minutes per revolution are inserted into the cylinders in which the batch settling tests are performed.

Considerable judgment is required so that the de-

Locate Operating Zones in Actual Settler

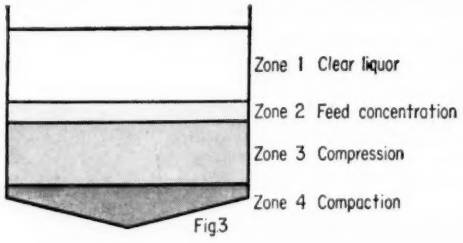


Fig 3

gree of rake action in the laboratory test will approximate that in the commercial unit. This is especially important where pickets are installed to aid settling. The improvement in settling rates obtained by the use of pickets apparently depends on the opening of additional channels for liquor to flow to the solids-liquor interface.

With incompressible crystalline pulps, the value of E may represent the final level of mud subsidence and can be used for estimation of the underflow concentration. With slimy compressible pulps, the final solid-liquid interface level will be below the value of E shown in Fig. 2.

Settler Design for Thick Pulps

Coe and Clevenger[5] presented the first truly successful method for the estimation of area requirements for thick pulps. They assumed that the settling rate of a pulp is a function only of the local solids content. They further recognized that the settling pulp passes through all zones of concentration from the feed to the underflow discharge concentration.

Coe and Clevenger computed the area requirements by the simultaneous solution of two equations, the first of which is:

$$A = \text{Overflow rate}/R \qquad (11)$$

where R is settling rate in ft./hr. and overflow rate is in cu. ft./hr.

Eq. (11) is identical with Eq. (9) which is used to size settlers operating on thin pulps. The difference for thick pulps is that the overflow rate does not refer to the actual settler overflow but to the volume of liquid which remains to be disengaged from the solids as it settles at various concentrations between the feed and the underflow.

It is customary to refer to the unit area requirement A_u of a pulp or slurry. This may be defined as the area required to settle a slurry with a steady feed rate of 1 ton of dry solids per 24 hr. On this basis, Eq. (11) may be modified to the following:

$$A_u = \frac{1.333(F_w - D_w)}{(Sp.\ Gr.)(R)} = \frac{1.333(F_t - D_t)}{R} \qquad (12)$$

Coe and Clevenger developed by experiment the second simultaneous equation which is:

$$R = \phi F_w = \phi F_t \qquad (13)$$

Hence, the settling rate is a function of the local solids concentration.

In a typical test of the Coe-Clevenger method, a 1,000 ml. cylinder is filled and the initial settling rate noted. About 100 ml. of liquor is siphoned off and the remaining liquor and the mud is repulped. The initial or constant rate period of settling is again observed. This procedure is followed until the spigot discharge density is reached. These data are substituted in Eq. (12) and the maximum area found is employed for design purposes.

Experience has shown that the limiting area requirements as determined by Coe and Clevenger's method were located at either the feed concentration or at the entrance to the compression zone.* For this reason, most references advise stopping the Coe-Clevenger test at the beginning of the compression zone. However, recognition of the appearance of this zone is left to the judgment of the person performing the tests.

Later workers[10,13] have presented design methods that utilize a single batch settling test rather than a series of tests in the Coe-Clevenger technique.

According to the Talmage and Fitch procedure[18] a tangent to the settling curve as shown in Fig. 4 is drawn at any point. The settling rate at this tangent point and the extrapolation of the tangent line to the zero time give respectively the settling rate and the feed concentration of a slurry which would be identified with the settling rate. These values are inserted in the equation:

$$A_u = \frac{1.333\left(\frac{H_t}{N} - D_t\right)}{R_t} \qquad (15)$$

The Talmage-Fitch procedure does not assume that occurrence of the limiting area requirement of the compression zone lies at the entrace to that zone. Furthermore, experience has shown that application of this procedure to points deep in the compression zone gives unduly high estimates of the area requirements. Therefore, the Talmage-Fitch procedure should be applied at the entrance to the compression zone.

Roberts[16] has shown that if log $(H - E)$ is plotted against time, a sharp discontinuity is usually noted at the point of entrance to the compression zone. Application of Roberts' observation coupled with the Talmage-Fitch procedure is illustrated by the following example.

Settling data for a calcium carbonate slurry containing 52 grams/liter of solids were taken and the results plotted as shown in Fig. 4.

From the results obtained, compute the setting rate for the compression zone as follows:

$$R = \frac{(525 - 300)(60)(14.2)}{(1{,}000)(20)(12)} = 0.80 \text{ ft./hr.}$$

Apply Eq. (12) to compute unit area for compression zone.

$$A_u = \frac{1.333(525 - 175)}{(0.80)(52)} = 11.2 \text{ sq. ft./(ton)(24 hr.)}$$

Values for the feed concentration are 3.3 ft./hr. and 6.4 sq. ft./(ton) (24 hr.) respectively. Hence, the compression zone requires the greater area.

The safety factor to be applied requires a knowledge of the variation in unit area requirement in the pulp being handled to arrive at a statistically derived confidence level of operation. If the pulp in this test were considered average, the probable design unit area requirement would probably be about 15 to 20 sq. ft./(ton) (24 hr.). The actual value depends on the variation in observed settling properties.

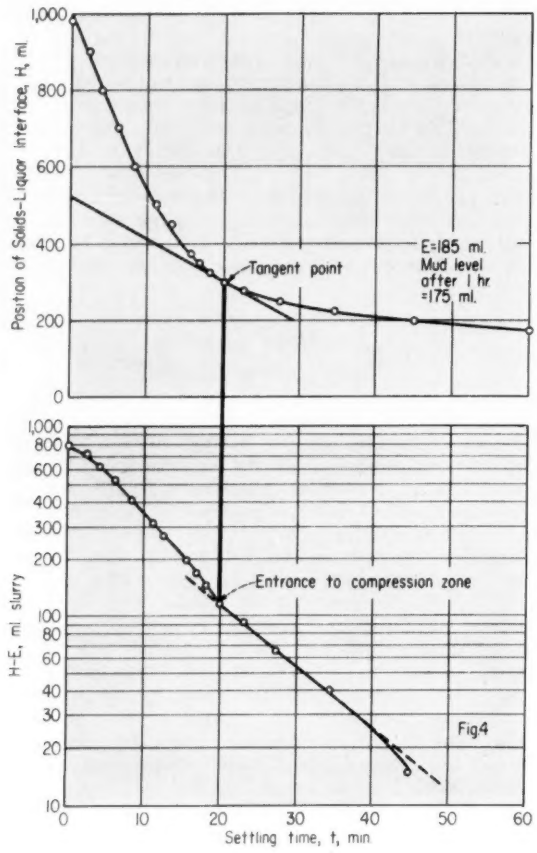
What Additional Factors Affect Settler Design

Other factors to consider in sizing a commercial settling vessel are: depth, underflow solids concentration, feed-well design, arrangement of overflow draw-offs, use of flocculating agents, rake speed and rake design. A measure of the required depth of the vessel may be obtained by empirical methods.

For example, a one-liter cylinder is filled with slurry

*A mathematical proof of this statement will be the subject of a paper by A. A. Anderson at the Southwest Regional Meeting of the American Chemical Society in Baton Rouge, Dec. 1959.

Roberts' Method Locates Compression Zone



Use Data to Find Unit Area for Compression Zone

Intersection of tangent line at the time zero, $H_t = 525$ ml.
Location of tangent point, $t = 20$ min.
Level at tangent point, $H = 300$ ml.
Equilibrium mud level, $E = 185$ ml.
Mud level at end of one hour is 175 ml. This solids-liquid level was judged to be more representative of the probable discharge concentration than the equilibrium value of 185 ml.
Distance from 0 to 1,000 ml. mark is 14.2 in.

at a concentration corresponding to the beginning of the compression zone. This is stirred very gently by a thin rod at hourly intervals. When further settlement appears negligible, the time is noted and the final solids concentration determined. Time is used to determine the volume by the formula:[18]

$$V_u = \frac{4t(G - Sp.\ Gr.)}{3G(S - Sp.\ Gr.)} \qquad (14)$$

The effect and value of depth in a settling vessel is a subject of some controversy. Some mud depth is essential to provide a driving force for the lateral movement and distribution of solids. In this manner depth is important in providing an efficient utilization of settling area and in preventing undue short-circuiting of partially thickened mud.

It is difficult to separate this useful function from the now questioned value of depth as a hydraulic driving force in squeezing more liquor from the mud. While increasing depth does increase this driving force, it apparently also increases the resistance for liquor movement to the surface in approximately the same degree.

Depth to be used in the design of a thickener is a matter of judgment. If Eq. (14) is used, an equal volume or at least several feet, is added for the clear liquor which functions to improve overflow clarity.

Underflow solids concentration is another factor requiring the application of judgment and a knowledge of the characteristics of the pulp. If the solids are of an incompressible, crystalline nature, the value of E may provide a satisfactory estimate of the underflow solids concentration.

With slimy solids, or where pickets are provided on the rake mechanism to provide additional channels for liquor to escape to the surface of the solids-liquor interface, the final solids concentration may be significantly higher than that computed from the equilibrium level value of E found in the batch test. Note also that Eq. (12) cannot be reversed to determine the underflow density as a function of the area provided in a commercial unit.

Use of multivalent ions and certain colloids to flocculate colloidal slimes is a long established practice. In the past few years, a number of natural and synthetic materials have been developed that have the ability to flocculate slimes. These consist of high molecular weight lyophilic substances. Such products are useful in increasing the settling rate of a slurry and allowing the use of a smaller vessel or of obtaining greater capacity in existing equipment.

Although several theories have been advanced, there appears to be no accurate means of predicting which substance will flocculate a given slime. Likewise, the amount of flocculant required and the optimum technique for its addition cannot be predicted. These factors must be determined by laboratory experiment.

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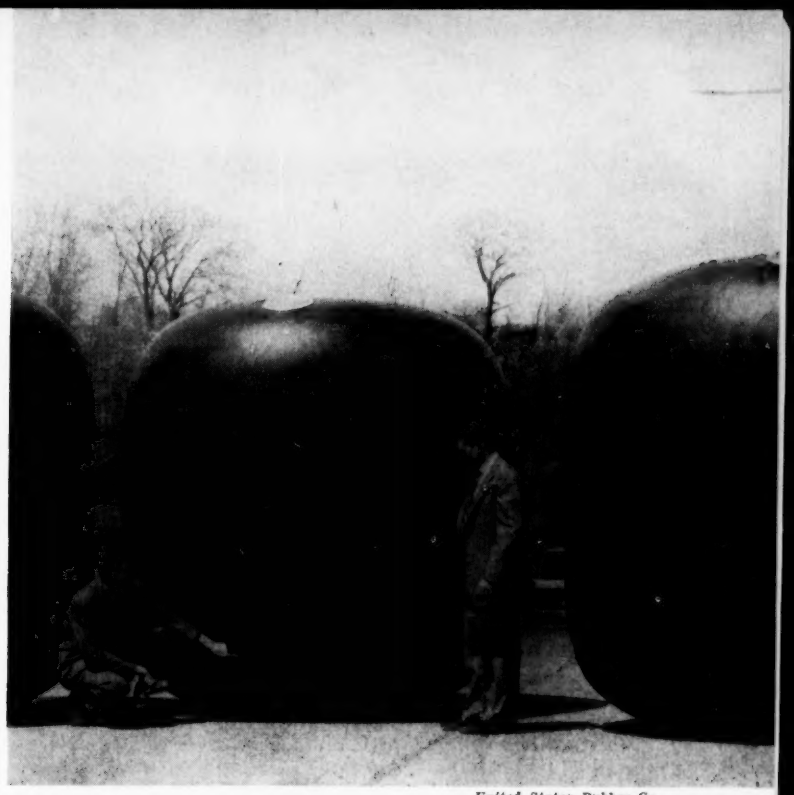


United States Rubber Co.

One of several recently developed bulk handling schemes, collapsible containers save much space . . .

NEW Containers Bridge Size Gap

MUCH attention has been given to the problem of handling dry materials in bulk. The standard methods of handling and transporting these materials, in paper bags, drums and car-load lots, require a great deal of handling and attendant expense. Often there are no adequate substitutes since to some users each method has its own advantages that outweigh its disadvantages.

In recent years, several new systems for material handling designed to bridge the gap between bags and drums and the large installations required for carload lots have been developed. These systems generally permit handling the material in larger unit quantities than do bags and drums and incorporate not only the containers themselves, but also the means of handling them.

One of these systems uses rectangular bins, fabricated of steel, stainless steel, magnesium or aluminum. These bins are generally 42 in. x 48 in. on the base dimension and between 5 ft. 9 in. and 8 ft. 3 in. tall, with capacities from 74 to 110 cu. ft., considerably more than the standard 55-gal. drum. The loads handled will vary from 3,000 to 5,000 lb., depending on the product.

In addition to containing larger quantities than drums, these containers are designed to facilitate loading, transporting and emptying. The containers are loaded through the top in much the same manner as drums or bags. The advantage of the containers is that less handling is required to load the same amount of material.

Being hermetically sealed and rectangular in form, these bins are easily shipped in the open on any flat bed conveyance with maximum use of available space. A standard flatcar will accommodate 100,000 lb. of payload. As many as 16 bins can be carried on a flat-bed truck. A carload of material in bins will occupy only 400 sq. ft. of space in storage when stacked two high, much less than the equivalent in bags or drums..

Since one container is a load for a standard lift truck, no special handling or moving equipment is required.

The bins discharge through a special gate in the bottom. This feature requires additional equipment for transferring the contents of the bins to larger storage facilities or directly to process as required. Again, much less handling is required than to transfer the same amount from drums, even when special drum handling equipment is available.

Since the bins discharge through the bottom, it is not necessary to overturn them for emptying. The special equipment designed for handling the discharge permits operation without exposing the contents. It will even permit use of the con-

Tote System, Inc.

Metal bins holding 3,000 to 5,000 lb. are easily handled by one man.

tainer as a feed hopper feeding directly into a screw conveyor. Thus the container may be used as part of the process equipment itself.

These bins are not collapsible and cannot be nested which means that they must be deadheaded back to their point of origin while occupying as much space as full bins. However, arrangements with the railroads and railroad equipment lessors are available which greatly reduce or eliminate the costs of deadheading.

In some cases these containers are used only for in-plant handling. Shipments are received at the plant in conventional carload lots, then transferred to the containers where the material remains until used.

Collapsible Containers

Another method of bulk materials handling which is becoming increasingly popular is the collapsible rubber container. The best known of these are larger than the bins previously mentioned, being 8 ft. in diameter and 8 ft. high, with a capacity of about 300 cu. ft. and handling loads of around 10,000 lb.

These containers are made of rubber but are reinforced by steel cables which pass from a lifting ring on top through the interior to the bottom of the bag. Thus the load is not taken by the relatively weak material of the container but by the cables and reinforced bottom. Since the containers must be handled by the lifting ring in the center of the top, special lift trucks and cranes are required for handling them when loading and unloading, and for in-plant transportation. They are much too heavy and too large for lifting from the bottom with fork-lift trucks.

Filling of the containers is most conveniently done by carrying the material into and out of the container in a stream of air or other gas. This means that auxiliary equipment is required for full utilization of these containers.

Because of their large capacity, the containers are conveniently tied directly to either the producing or using process. The product stream can be run directly to the container through the necessary conveying equipment. In the same manner, the material can be fed directly to the process from the container without the necessity for intermediate storage bins, feed hoppers or conveying equipment. A minimum of handling is required for a moderate sized process.

As mentioned, these containers are collapsible. When empty, they can be folded to a size far smaller than their size when full. For example, a standard railroad car will carry seven loaded containers but can hold 70 empty collapsed containers. The advantages of this feature are obvious, it is only necessary to deadhead one car of empties for each ten cars of loaded containers received.

Being completely weatherproof, the collapsible rubber container lends itself readily to outside storage and open transportation.

Cardboard Boxes

Quite a little work is being done with cardboard containers having a capacity of from 1,000 to 3,000 lb. Normally these are one trip containers and are primarily adaptable to small or medium size users. The cost per 100 lb. for the cardboard container is about the same as for paper bags, but the user does obtain a more efficient method of car unloading and in-plant handling.

Sometimes the cardboard containers are designed for collapsing and return, which reduces the cost per container and requires minimum deadheading. However, the additional handling involved may offset the advantages gained.

Other Systems

Much of the progress in the field of containerization is not in the handling of bulk materials, as we have been discussing here, but in the handling of conventional dry cargoes. In this category fall "piggy-back" truck bodies, which may be transported from ship to train to truck without disturbing the contents, and palleted shipment of drums and bags as opposed to individual shipment of these items. Such containerization, while valuable, is not designed for the transportation or, particularly, in-plant handling of bulk materials and is not of primary concern to the chemical engineer.

Containerization for handling bulk dry materials is still in its infancy. We have covered here in small detail some of the advantages and disadvantages of conventional systems and of some of the newer methods. We have not attempted to cover all the details and economics of one type of container versus another or against other bulk handling techniques. Nor have we attempted to describe in detail all of the containerization systems available. Any such survey must be obsolete almost as soon as it is published as undoubtedly dozens of other ideas and designs will be forthcoming.

This article is based in part upon papers presented by F. J. White, Jr., of Tote System, Inc., and N. H. Brown, Jr., of United States Rubber Co. at the Semi-annual Meeting of the ASME, June 14-18, 1959.

How to Receive and Unload . . .

Liquefied Compressed Gases

Liquefied compressed gases can give you some sticky handling problems. Here, in this report, is the necessary know-how you need before starting

F. R. FETHERSTON, Secretary-Treasurer, Compressed Gas Assn., Inc., N. Y.

Liquefied compressed gases commonly shipped to users in bulk by rail or over the highway in cargo tank trucks are : anhydrous ammonia, liquefied petroleum gas (LP-gas), chlorine, methyl chloride, sulfur dioxide and, broadly, liquefied fluorinated hydrocarbons.

In liquid form, carbon dioxide and nitrous oxide are liquefied compressed gases, and these are so shipped. However, due to special considerations, these two gases will be covered in a future article.

All subject gases are shipped in single-unit tankcars. There are several ways to unload them. Some are also shipped in bulk by rail in multi-unit (TMU) tankcars. In such shipments a number of large containers, usually 15, are transported on a car tank underframe for removal therefrom and subsequent movement to point of use.

Whichever gas these containers hold, the method of removing them from the car underframe is identical.

Method of withdrawing their content at point of use is the same except with sulfur dioxide and liquefied fluorinated hydrocarbons, which may require heat to effect transfer.

Never use direct heat in any form to unload containers holding the other compressed gases. Where you need heat to transfer the contents of sulfur dioxide or liquified fluorinated hydrocarbon containers, use it only as prescribed by the manufacturers.

"Cargo tank truck" is an industry term used to designate a truck on which a tank is mounted to transport liquids or gases. "Cargo tank truck," "tank truck," and "transport tank truck," as used in this article, are synonymous. In Interstate Commerce Commission (ICC) Regulations, all are defined as motor vehicles on which cargo tanks are mounted as a permanent part of the vehicle itself. Capacity of the tanks range up to approximately 10,800 gal.

Safe unloading of single-unit tankcars, safe removal of containers from TMU tankcars, unloading of these containers at point of use, and safe unloading of cargo tank trucks is a matter of applying known safety procedures.

You can safely handle and unload liquefied compressed gases only:

- When their physical and chemical properties are understood.
- When regulations and standards governing their handling are complied with fully.
- When you realize that accidents are the result of man-failure.

Accidents have happened during unloading operations. Results, in some cases, have been property damage, personal injuries and loss of life.

The Compressed Gas Association, Inc., which is and has been active for almost 50 years in developing procedures for safe and efficient transportation, storage and handling of all compressed gases, as well as the related standards, adamantly takes the position that there can be no leeway, short cuts, laxity, nor carelessness on the part of handling personnel during any stage of the unloading operations.

Safe procedures are spelled out precisely in regulations, standards, the literature of technical associations, and in the instructions of the compressed gas manufacturers. You must follow these to the letter and spirit.

1—Equipment and Techniques

Start with careful selection of personnel charged with the responsibility for unloading. Never send a boy to do a man's job. Do choose reliable, intelligent men with a high sense of responsibility preferably from the chemical operator level and arrange to train them thoroughly.

Training must be continuous. Failure to keep personnel well trained is a source of danger. Include your medical officer, safety supervisor and fire protection engineer (if you have them) in your training class.

Your compressed gas manufacturer is the key to your training program. He's every bit as much concerned with safety in unloading operations as you are.

He will supply technical data describing the physical and chemical properties of the compressed gas in question, knowledge concerning its characteristics, information about protective equipment, measures to take to prevent an accident before it happens and the corrective and first-aid steps in case of an accident.

Make it a *must* for your personnel to study and digest these data until they are as familiar as the A, B, C's.

Some manufacturers of certain compressed gases furnish qualified technical representatives to train your personnel in every step of the unloading procedure. Take advantage of this service where it is available.

Bear in mind that employees leave a company, or they may be promoted or transferred to other departments or locales, and so are relieved of their unloading duties. In such circumstances, be sure the replacement is thoroughly trained in unloading procedures before you allow him to participate in the operation. Many unloading accidents have been traced to failure to observe this obvious precaution.

Who's Responsible for Unloading Operations?

With single-unit tankcars and TMU cars, full responsibility for unloading them safely rests with you, the consignee. In unloading cargo tank trucks, where equipment for making the transfer to the consignee's storage facilities is a part of the vehicle itself (photograph on p. 94) responsibility for safe unloading rests with the carrier or the transfer owner.

In cases where equipment for transferring a compressed gas from a cargo tank truck is provided by the consignee, the consignee then has a vested interest in the transfer operations and to this extent shares responsibility for safety. There are exceptions to this: some users own their cargo tank trucks and these users are responsible for unloading operations.

Tankcars Are Similar

Except for capacities and specifications governing fabrication of their tanks, single-unit tankcars used in liquefied compressed gas service are similar.

Tankcars for Liquefied Compressed Gases Have Identical Valve Arrangements—Fig. 1.

A Liquid eduction valve

B Vapor valve

C Safety relief valve

D Gaging device
1. Gaging pointer
2. Gage rod lock
3. Gage rod valve
4. Gage rod
5. Gage rod brake
6. Packing gland nut
7. Protective housing
8. Gasket
9. Gaging rod shield vent holes
10. Lubricator assembly

E Sample valve

F Thermometer well

G Excess flow valves

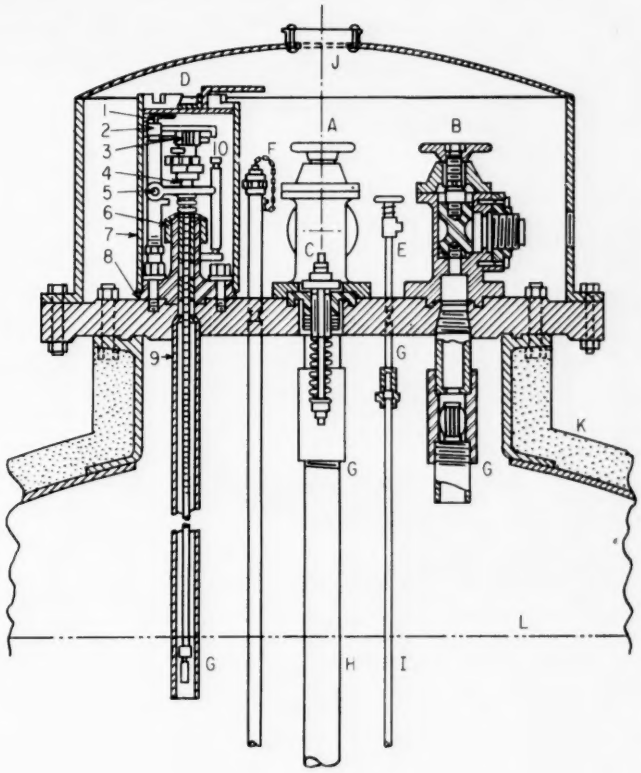
H Liquid eduction pipe

I Sample line

J Screen

K 4-in. insulation

L Liquid level



Single-unit tankcars for transporting anhydrous ammonia and LP-gas are insulated or uninsulated while those used to transport the other liquefied compressed gases are insulated to protect against atmospheric temperature differentials. The cars are never filled liquid full, but have a vapor space, termed outage, the volume of which is calculated for each specific gas.

Arrangement of their valves and fittings is identical (Fig. 1). These are located on a manhole cover plate on top of the car, not in a dome as such, but in a protective housing. The manhole cover is never removed for unloading. Unloading is only through the manually operated valves.

Usually there are four such valves. Two are in line with the track (toward the ends of the car) and are connected to liquid eduction pipes that extend to the bottom of the car. These are the liquid valves.

Two valves (in some cars only one) are mounted towards the sides of the car, and these terminate in the car's vapor space. These are the vapor valves.

In cases where cars have only one vapor valve, a liquid level gage may be installed in the space otherwise occupied by the second vapor valve. Such cars usually have a thermometer well.

Excess flow check valves are installed on the liquid eduction lines of some single-unit tankcars. These operate when you open the liquid valves too quickly; the unloading rate is too high; or a break or rupture occurs in the liquid unloading lines. When you correct the difficulty, reopening the check valves is accompanied by an audible sound.

Single-unit tankcars in liquefied compressed gas service are protected from excessive internal pressure by a spring-loaded safety relief valve located in the center of the manhole cover plate. Valve setting depends upon the specification tankcar used.

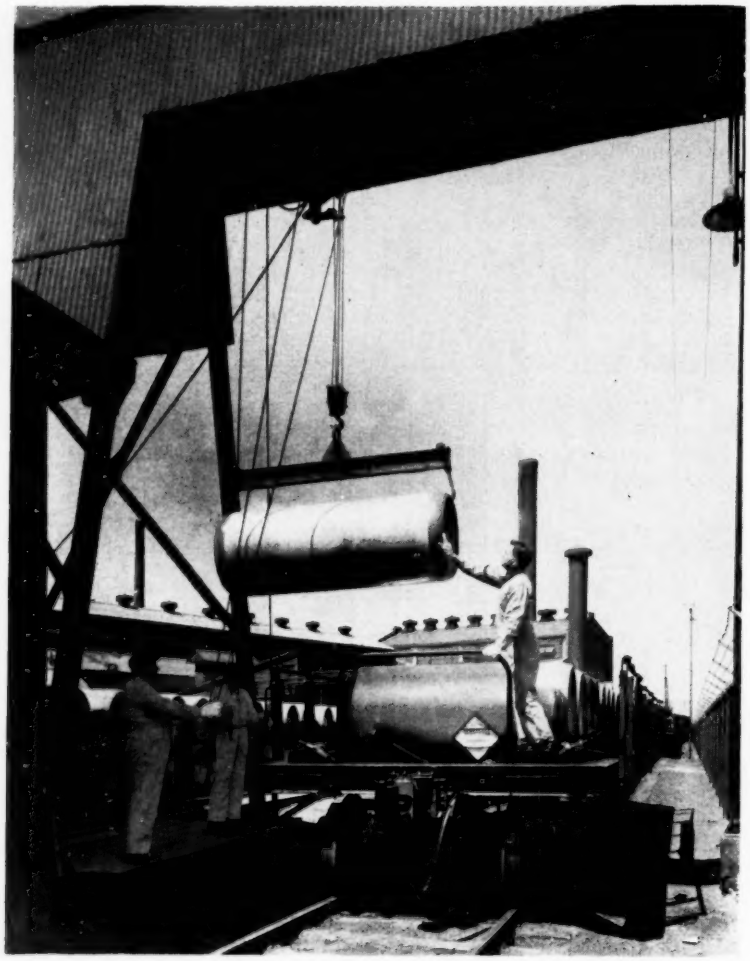
At high temperatures, such as you might encounter in a fire, the safety relief valve prevents build-up of dangerous internal pressures. Unloading procedures must be such that the pressure developed doesn't cause the safety relief valve to blow.

Removing TMU Containers

Liquefied compressed gases transported in multi-unit (TMU) tankcars are: anhydrous ammonia, chlorine, methyl chloride, sulfur dioxide and liquefied fluorinated hydrocarbons.

Although LP-gas isn't generally shipped by TMU cars, ICC regulations provide for their use.

In TMU shipments, these gases are contained in large cylinders commonly known as "one ton containers." This name comes from



TMU CONTAINERS being removed with hook, hoist and trolley.

their capacity in terms of chlorine. They are shipped on a car underframe; shipments usually consisting of 15 containers. Fewer than 15 units may be shipped as a TMU car, but this arrangement is impractical since your freight charge is figured for the full 15 containers at prevailing carload rates.

Before removing containers from the car frame, you must observe the same ICC regulations concerning personnel, setting brakes, blocking wheels of the car and posting caution placards as in unloading single-unit cars.

Full containers are removed from the underframe by a lifting hook in combination with a hoist on a trolley (see photograph above) or a jib boom. Never use a lifting magnet nor a sling, either rope or chain, to unload or otherwise handle these containers.

Containers must be protected from shock which might damage valves, fuse plugs or the container itself. Keep valve protecting hoods in place at all times when containers are being moved.

When containers are trucked from the rail siding to the storage area, they must be placed on saddles on the truck. Preferably, clamp them down to prevent shifting and rolling.

► **Valves and Safety Relief Devices** —Each container has two valves, each equipped with a ½-in. eduction pipe. When the container is positioned horizontally with a slight downward pitch and one valve is directly above the other, the top eduction pipe ends in the vapor phase and the eduction pipe of the bottom valve in the liquid phase.

You can withdraw either liquid or vapor by connecting to the appropriate valve.

These two valves are protected by hoods. Keep hoods in place at all times except when the container is connected for withdrawing its content.

Each container is protected by fusible plugs in each head. The fusible metal is designed to soften or melt at 157-165 F. Don't tamper with the fusible plugs under any circumstances. It is recommended that containers never be allowed to reach a temperature exceeding 125 F.

ICC regulations provide that TMU containers may be transported under certain conditions on trucks or semi-trailers. They must be chocked or clamped on the truck to prevent shifting. You must have adequate facilities available when transfer in transit is necessary.

Take These Precautions First

Comply with all rules set forth in Sec. 74.561 through Sec. 74.563 of ICC Regulations.

Once caution signs required by Sec. 74.562 are posted, don't allow the tankcars so protected to be coupled or moved.

Do not permit other cars to be placed on the same track except after notifying the person who placed the signs, and provided there's a standard derail properly set and locked in the derailing position between the car being unloaded and cars to be set on the same track.

Never permit a compressed gas to be loaded into a container that holds or has held another compressed gas.

Unloading valves must not be opened until caution signs are posted, nor the signs removed, even temporarily, until valves are closed and lines disconnected.

When tankcars are placed on a dead-end siding, protect them on the switch end by a derail; if on open-end siding, at both ends.

Follow faithfully all procedures recommended by your compressed gas manufacturer.

In the case of flammable gases, establish a firm "No Smoking" rule

for all unloading personnel. Make it mandatory that the rule is observed during the entire unloading operation.

Have your personnel check the area for all open flames and have flames extinguished before starting operations. Instruct your personnel to prevent all persons in the vicinity from smoking, carrying any flame or lighted cigar, pipe or cigarette.

Make sure the car is level so it can be gaged correctly and unloaded completely. Your compressed gas manufacturer will supply data for sampling procedures and for gaging tankcars. The American Petroleum Institute publishes a tentative code for gaging tankcars containing compressed gases derived from petroleum.[2]

Check These Regulations Before Starting Any Unloading Operation

In the U. S., the Regulations of the Interstate Commerce Commission (ICC) govern unloading of compressed gas shipped in interstate commerce. In Canada, the Regulations of the Board of Transport Commissioners for Canada (BTC) govern the operation, and these parallel the regulations of the ICC.

In addition, there may be local, state or provincial regulations. Consult your compressed gas manufacturer as to the existence of the latter.

Interstate Commerce Commission Regulations are published in Agent H. A. Campbell's Freight Tariff No. 10, reissues thereof, and supplements thereto.[1] Obtain a copy. Make sure that excerpts from these regulations, as they pertain to compressed gas, are placed in the hands of your unloading personnel for study.

If you are building a new plant, Sec. 74.560 of the ICC regulations tells the circumstances under which you must own (or lease) your rail siding. This section also states the exceptions and circumstances under which compressed gas tankcars—particularly TMU cars for shipping anhydrous ammonia or chlorine, and single-unit tankcars for shipping anhydrous ammonia, liquefied hydrocarbons or liquefied petroleum gas—may be unloaded from carrier tracks.

TANKCARS—Sec. 74.561 gives the regulations governing unloading of all compressed gases, including liquefied compressed gases, from tankcars. Refer to it for full requirements. Significantly, this section emphasizes the importance of personnel by placing this subject first on the list.

Following items are excerpts from this section:

"Unloading operations should be performed only by reliable persons properly instructed and made responsible for careful compliance with this part.

"Brakes must be set and wheels blocked on all cars being unloaded.

"Caution signs must be so placed on the track or car as to give necessary warning to persons approaching car from open end or ends of siding and must be left up until after car is unloaded and disconnected from discharge connection. Signs must be of metal or other suitable material, at least 12 by 15-in. in size and bear the words 'STOP — Tank Car Connected,' or 'STOP—Men at Work,' the word 'STOP' being in letters at least 4-in high and the other words in letters at least 2-in high. The letters must be white on a blue background.

"Care must be taken to avoid spilling any of the contents over tank or car.

"Unloading connections must be securely attached to unloading pipes . . . before discharge valves are opened.

"Tankcars must not be allowed to stand with unloading connections attached after unloading is completed, and throughout the entire period of unloading, or while car is connected to unloading device, the car must be attended by unloader."

CARGO TANK TRUCKS—Where responsibility for unloading cargo tank trucks rests with the common carrier or transport owner, his operator will be trained in all phases of the operation. He will be throughly familiar with the regulations, both federal and local.

However, since the operation is performed within the battery limits of your (the consignee) plant, you have an interest.

As a matter of information, general regulations governing cargo tank truck unloading are stated here. Check these regulations and make sure you follow them.

Subpart B of Part 77 of ICC Regulations applies to unloading compressed gas cargo tank trucks. In part they provide that:

There shall be no smoking on or about the vehicle during unloading. Extreme care shall be taken to keep fire away and to prevent persons in the vicinity from smoking, lighting matches, carrying any flame or lighted cigar, pipe or cigarette.

The handbrake of the transport must be securely set and other reasonable precautions taken to prevent any motion of the vehicle.

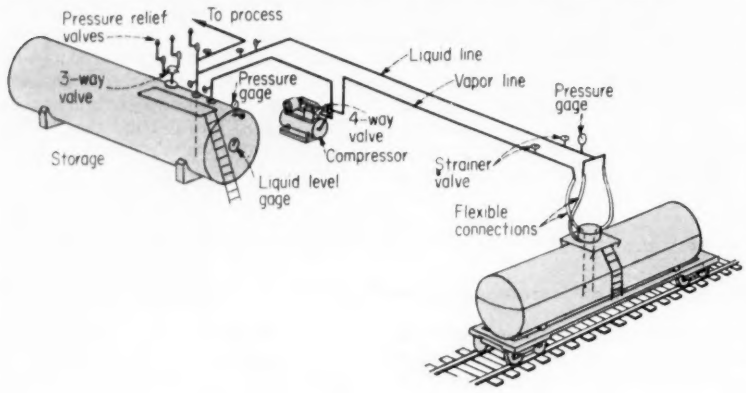
No tools which are likely to damage the tank shall be used.

The transport must be attended at all times. Under ICC Regulations the delivery hose, when attached to the vehicle, is declared a part thereof.

Unless the engine of the transport truck is to be used for operation of a transfer pump of the vehicle, the engine must be stopped during unloading; and, in any event, care should be exercised to prevent the ignition of vapors. Unless the delivery hose is equipped with a shut-off valve at its discharge end, the engine of the motor vehicle shall be stopped at the finish of the unloading operation while the discharge connection is disconnected.

No tank motor vehicle shall be moved, coupled or uncoupled when loading connections are attached to the vehicle, nor shall any semitrailer or trailer be left without the power unit unless chocked or equivalent means are provided to prevent motion.

Using a Compressor to Unload a Single-Unit Tankcar—Fig. 2.



Then: General Precautions

Phone or wire your compressed gas manufacturer immediately for assistance and instructions if:

- A tankcar is received in bad order. Meanwhile, don't attempt to unload it.
- In event of failure of fittings or a leak that you can't readily repair by simple adjustment or tightening of the fitting. Meanwhile, evacuate the area around the car and permit only properly instructed and protected personnel to enter the area.
- If the tankcar cannot be unloaded after following all instructions.
- In event of an accident of any kind.

In addition to notifying your compressed gas manufacturer concerning the above, also notify your nearest ICC inspector. He's usually very helpful in correcting these problems. You can get his name, address and phone number by writing to: Interstate Commerce Commission, Washington, D. C.

It's illegal to ship a defective or leaking tankcar. If a car is in bad order or if there's an accident, telephone the car owner. He can lend some valuable assistance.

Insist that your personnel observe the following:

- Never introduce a compressed gas into a tankcar or container of any kind that holds or has held another compressed gas or chemical.
- Never introduce water or other material into a tankcar or any other compressed gas container.
- Don't remove tankcar valves under any conditions.
- Never hammer tankcar fittings in an attempt to open excess flow check valves, nor for any other reason.
- Never enter empty tankcars for any purpose whatsoever.
- Don't attempt to correct leaks at unions or other fittings in a line with a wrench while the line is under pressure.
- Never fill your storage tank liquid full; the consequences are very serious. Observe readings on gaging devices and fill only to allowable maximum filling level.
- Where compressor, pump or piping, handling a heavier-than-air compressed gas, is located in a trench or pit, caution the operator to check these low spots for vapors since they can occupy an enclosure or trench by displacing the air.
- When all unloading connections seem to be tight, pressurize the system and check for any leaks.
- Never break a hose coupling under pressure.

Because of their low boiling points, the subject gases must be liquefied under pressure. On release at normal temperatures and atmospheric pressure the liquids vaporize rapidly.

In contact with skin surfaces this evaporation of liquids causes severe burns (frostbite) and when large quantities of the liquid are involved, deep and severe freezing of the area in contact with the liquid results.

For this reason, it's important for unloading personnel to wear protective gloves to prevent coming into contact with liquid when breaking hose connections or when venting the transfer hose. Large-lensed spectacles or goggles should be worn to prevent liquid from contacting the eyes and causing possible injury due to freezing of the moisture in the eyes.

As to gasmasks, protective clothing, fire extinguishers and related safety equipment, make certain these are of approved types, always in perfect condition and stored in areas that are accessible in case of a leak. See to it that your personnel are thoroughly instructed in their use and keep personnel alert and continuously trained by occasional "dry runs."

Tankcar Transfer Lines

Single-unit tankcars in liquefied compressed gas service are always unloaded from the top.

Transfer lines and their flexible hoses, or unloading coils, must be of materials suitable for transferring the particular gas being handled as recommended by the compressed air manufacturer. When not in use, plug the hoses or coils to prevent accumulation of moisture and dirt.

Different methods of unloading require special valves and equipment. In all cases, the liquid unloading line is equipped with a pressure gage and shut-off valve.

With the exception of chlorine, liquid and vapor lines are vented to atmosphere through small, manually operated, bleeder valves. While bleeder valves are installed in chlorine transfer lines, chlorine isn't vented to the atmosphere but to a lime or caustic disposal system.

In all cases, never break a hose coupling or connection while the transfer line is under pressure.

Mechanical Unloading Methods

Liquefied compressed gases are transferred from single-unit tankcars to storage (in case of chlorine, direct to process) by pressure differential. Before unloading, check the pressure in the tankcar and in the storage tank to determine which is higher. If pressure in the tankcar is the higher of the two, then mechanical means will not be required to transfer the liquid. However, as pressure between the car and storage equalizes, mechanical methods are required to restore it.

Methods and gases to which they must be applied are:

By compressor—Anhydrous ammonia, LP-gas, methyl chloride, sulfur dioxide and liquefied fluorinated hydrocarbons.

By vaporizer—Anhydrous ammonia. (This method is not commonly used.)

By direct-acting liquid pump—LP-gas.

By air or gas repressuring—LP-gas.

By air-padding—Chlorine and sulfur dioxide.

All equipment used must be designed for the particular gas being transferred.

▶ **Weighing**—This is often the most desirable method for determining when a car is empty of liquid. Some transfer systems include a sight glass in the liquid discharge line. When vapor is observed in this glass it indicates the car is emptied of liquid. Where cars are equipped with a sample valve, you can check indication given by the sight glass by opening the sample valve slowly.

▶ **Unloading With Compressor**—Suction side of the compressor is connected to the storage tank's vapor line: discharge side is connected to one or both vapor valves on the tankcar through suitable transfer hoses.

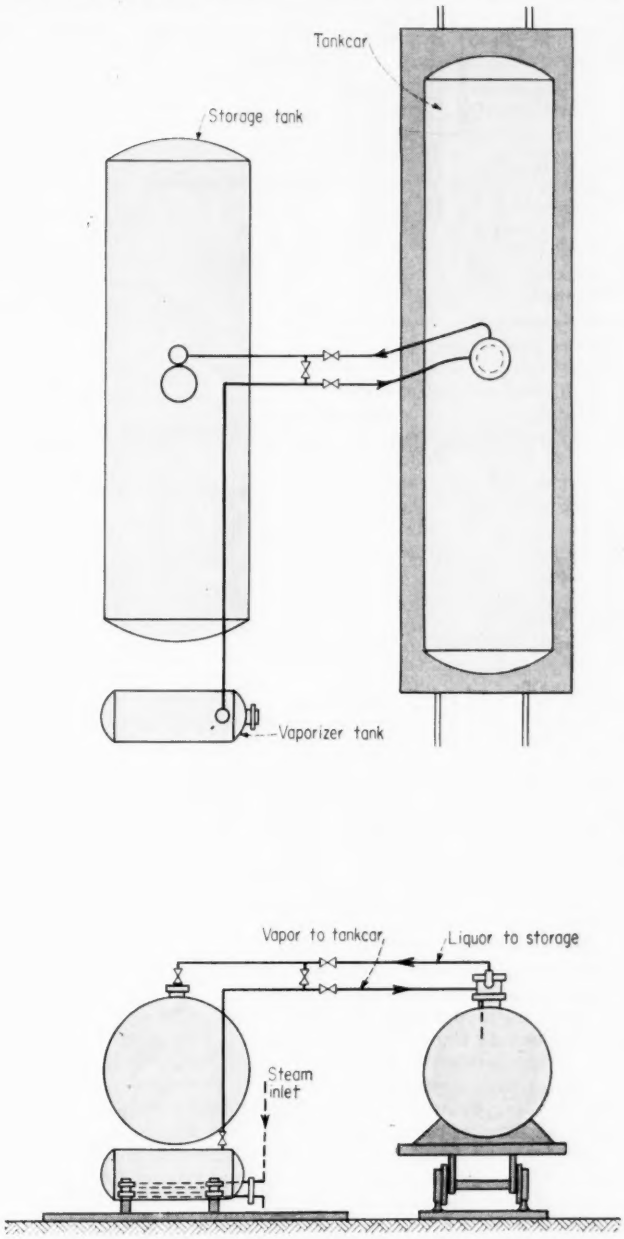
The compressor withdraws and compresses vapor from the storage tank and transfers it to the tankcar's vapor space. In this way, the desired pressure differential is created which transfers liquid to storage from the tankcar through a hose connected to the liquid line on the tankcar and to a vapor line from the storage tank. A typical compressor unloading setup is shown in Fig. 2.

To withdraw vapors from the tankcar after it's empty of liquid, the car's liquid valve is closed, and the compressor's reversing valve turned. The compressor then withdraws most of the vapor in the tankcar and returns it to storage. If the compressor doesn't have a reversing valve, its suction and discharge connections are reversed to accomplish this result.

Allow some vapor to remain in the car to prevent a vacuum from developing that may damage the car.

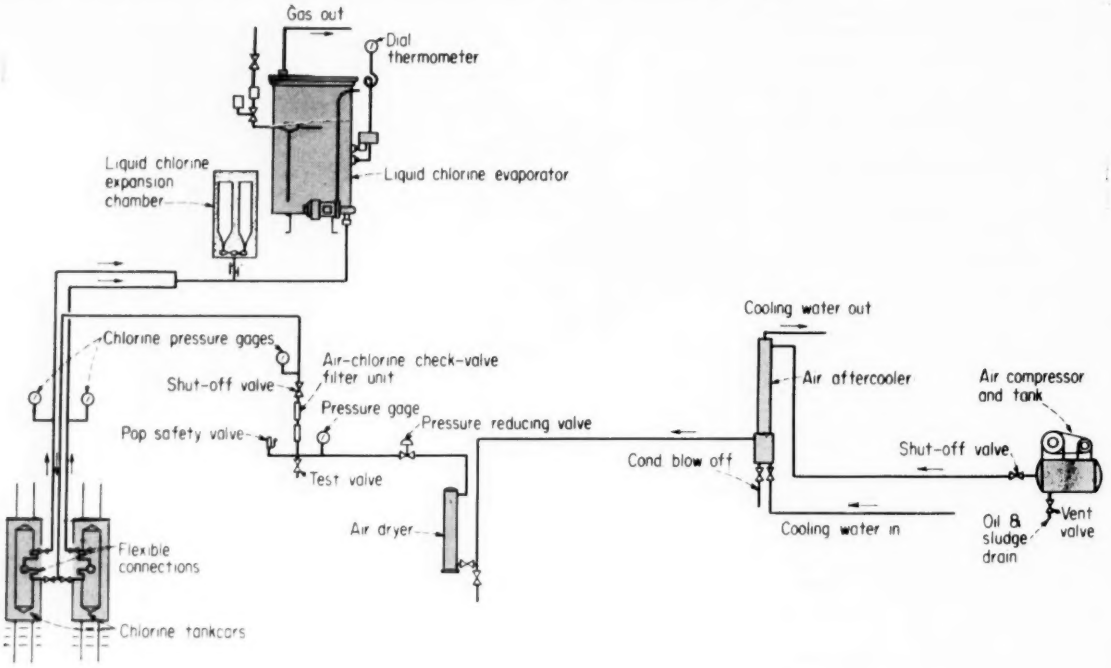
When using a compressor, take precautions to prevent lubricating oil from contaminating the tankcar or storage tank. Do this by installing a suitable oil trap or mist extractor on both the suction and discharge sides of the compressor. Drain the trap or mist extractor before each unloading.

Unloading a Single-Unit Tankcar by Steam Vaporizer—Fig. 3.



▶ **Unloading With Vaporizer**—Liquid from storage is charged into a vaporizer, sometimes termed an evaporator, and its vapor section is connected to one or both vapor valves on the tankcar. When heat is turned into the vaporizer, the vapor exerts pressure on top of the

Unloading Two Single-Unit Chlorine Tankcars by Air-Padding—Fig. 4.



liquid in the tankcar causing it to flow to storage.

By this method, you can transfer all of the liquid to storage but the vapor remains in the car. Steam vaporizer method of tankcar unloading is illustrated in Fig. 3.

► **Unloading With Pump**—When a direct-acting liquid pump is used for transfer, an equalizing hose assembly is connected to the storage tank vapor line and to the tankcar vapor valves. This equalizing hose is used if storage tank pressure is greater than tankcar pressure and to save wear and tear on the pump and motor.

If the tankcar pressure is higher than storage tank pressure, allow the pump's bypass to remain open as long as the rate of liquid flow from the tankcar to storage is satisfactory.

► **Unloading by Repressure**—You must use an air dryer to unload by this method.

Connect the repressuring hose assembly to the tankcar vapor valve and to the compressed air or gas supply line. This line must have a check valve and an atmospheric vent.

There should be a pressure gage on the repressuring line near the tankcar vapor valve to permit readings on the tankcar pressure. If the difference in pressure is less than 10 psig., no restriction of flow is necessary. If a long unloading line is involved, you may increase this differential slightly.

While air (or any fluid) is passing through a pipe at high velocity, the pressure gage mounted directly in the pipeline reads much lower than the pressure existing at the source of the pressure. Where the air or gas supply is at a much higher pressure than that desired in the tankcar, there have been cases of relief valves on the tankcar releasing while the pressure gage in the air or gas line indicated a safe pressure.

By either placing the pressure gage directly in the line to the tankcar vapor valve or stopping the flow of air or gas through the pipeline momentarily, you can get an accurate reading and overcome false readings.

Maintain from 5 to 10 psig. more pressure on the tankcar than on the storage tank.

Open the repressuring line valve just enough to maintain the desired differential unless you use a differential controller. Take care to avoid building up too great a differential or else the tankcar excess flow valves will close.

As in the compressor method, a flow of gas instead of liquid through the sight glass, if one is installed in the system, indicates the car is empty. When the tankcar is empty, first shut off the air or gas repressuring supply, and then proceed in the same way as when you are unloading with a compressor.

Don't use untreated artificial gas for repressure or you may contaminate the shipment or the tankcar. You may use coal gas, blue water gas, coke oven gas, producer gas or natural gas, if properly cleaned. Also, butane-air or propane-air mixtures may be used to unload by gas repressure.

Repressuring gas or air should be as dry as possible to eliminate the addition of water to the product as well as to prevent freezing troubles during cold weather. Unloading by air or gas is impractical for propane or high propane con-

tent mixtures because of the pressure involved.

► **Unloading With Air-Padding**— When you use air-padding, it's imperative that clean, oil free, cooled, dry compressed air is introduced into the tankcar's vapor space through its vapor valve to transfer the car's liquid to storage (or as in the case of chlorine, direct to process).

The set-up consists of an air compressor and its tank equipped with a pressure regulator and an air dryer with appropriate valves and gages as shown in Fig. 4. A dependable check valve must be incorporated in the air-padding line as also shown. Never use a plant air system for air-padding since the possibility exists that vapors can be drawn into the plant air system.

Preparing for Unloading

When the tankcar is protected as required by ICC regulations, break the seal on the protective cover housing the unloading valves and related equipment, and check (by the means prescribed later for the separate gases) the various valves for leaks which may have occurred in transit.

If any working parts of the tankcar are in bad repair, notify your supplier at once. Don't tamper with the car in an effort to correct the trouble. Instead, phone or wire the compressed gas manufacturer, state the trouble, and follow his instructions.

Make the car ready for unloading by carefully and cautiously removing the plugs from the car's liquid and vapor valves. The liquid transfer assembly is connected to the tankcar's liquid valve, or valves. The vapor line transfer assembly is connected to the tankcar's vapor valve or valves.

If the pressure in the tankcar is higher than that in the storage tank, start the unloading operation by opening the tankcar's liquid valves (only one may be used, if desired) and then open all other valves on the liquid line toward the storage tank.

When pressure between tankcar and storage tank nears equalization, restore pressure in the tankcar by the method appropriate for the liquefied compressed gas being transferred. This proceeds by working from the source of the pressure to the tankcar.

If a compressor, vaporizer or a pump is used, open the vapor valve on the storage tank as well as all valves on the intake and discharge sides of the vapor transfer equipment.

Place the equipment in operation and open the vapor valve, or valves, on the tankcar.

If you use air or gas repressuring or air padding, place the equipment in operation, and open all valves leading to the tankcar with the tankcar's vapor valve or valves opened last. As in the case of liquid transfer, open these valves slowly.

The sight glass, when one is installed in the liquid discharge line, is observed by the operator, as are the pressure gages in the transfer lines, to determine when all liquid is removed from the tankcar.

When this is established, prepare the car for disconnecting (except in the case of chlorine, see page 94) by closing down liquid transfer lines first. Then, starting with the storage tank's inlet valve, close all valves up to and including the tankcar's liquid valve.

If you use a compressor on the vapor side and want to recover the vapors in the tankcar, shut down the compressor and turn its plug-cock, or reverse the vapor transfer lines on the compressor. Then, place the compressor in operation again to withdraw vapors from the tankcar to storage.

In shutting down the vapor transfer lines, close the tankcar's vapor valve first, and then successively close the other valves by working from the tankcar to the source of pressure. After bleeding off all transfer lines to atmospheric pressure through the small bleed and purge valves, located in the liquid and vapor lines, disconnect the flexible hoses or coils from the tankcar either by breaking the flanged connection or by opening up a pipe union.

Plug the unloading lines, as well as all tankcar valve openings and place the tankcar fittings in proper position.

Lower the tankcar's protective housing carefully and secure it in place with an iron pin. When signs protecting the car have been removed and all other regulations required by the ICC observed, inform the railroad agent that the car is empty and furnish him with return billing instructions.

Handling TMU Containers

With the exception of LP-gas, as previously noted, all subject gases are shipped in TMU containers. These containers may be removed from the car underframe when the car is spotted on carrier tracks provided the ICC specification regarding the presence of handling equipment is complied with. The cylinders are then transported by truck, as previously described, to the user's plant where similar handling equipment must be available. Cautions concerning the handling of these cylinders as earlier described (page 85) must be strictly observed.

Ton containers should be stored on the user's premises in a cool, dry place and protected against heat sources. You can make a convenient storage rack by supporting the containers at each end on a railroad rail or an I-beam. When containers aren't in use, keep the valve protective hoods in place at all times.

Store full and empty containers in different places to avoid confusion in handling. It is good practice to tag empties. Do not store containers near elevators or gangways or in locations where heavy objects may fall and strike them.

Never store containers near combustible or flammable materials. When containers hold flammable gases, keep them away from all ignition sources. Keep the storage room well ventilated and so arranged that you can remove any container with a minimum of handling of other containers. When practical, the storage room should be fireproof. Avoid storage in subsurface locations.

Make sure containers stored out-of-doors are free of debris, tall grass and away from public access. They should be kept clean and inspected regularly.

Never store containers holding a flammable gas or a gas that affects the respiratory system. Never place such containers where fumes can enter a ventilating system, nor where wind can carry fumes to populated buildings or populated areas

Use containers in the order received. Observe precautions stated under "Valves and Safety Devices" (page 86) as well as the general and specific rules for unloading tankcars (page 87).

Except when recommended by the compressed gas manufacturer, TMU containers should not be manifolded to withdraw contents from two or more containers simultaneously.

To discharge the content of TMU container, place it so that it's in a nearly horizontal position with a slight downward pitch (about 1 in. over-all) toward the valves. When the container is placed so that one valve is directly above the other, you can withdraw vapor from the upper valve or liquid from the lower.

Assembly for withdrawing a container's content usually consists of a transfer line equipped with a pressure reducing valve, rotameter, control valve and diffuser. In chlorine service the system may include only a pressure and control valve.

For all subject gages, test TMU container connections and transfer piping for leaks as later described under handling of each specific gas.

Sometimes, it's necessary to use heat to help the flow of either gas or liquid from sulfur dioxide or liquefied fluorinated hydrocarbon ton containers. When you use heat, the method approved by the compressed gas manufacturer must be followed. Exercise great care, as fusible plugs in ton containers melt at 157-165 F. Never allow containers to reach a temperature above 125 F. Never apply blow torches or steam hoses nor use an open flame from any source or heat them.

Unloading Cargo Tank Trucks

All subject liquefied compressed gases are, or may be, shipped in cargo tank trucks conforming to ICC specification MC-330. While it is permissible to ship chlorine in cargo tank trucks of this specification in the U. S. and Canada, no shipments of this kind have been made to date. Similarly, methyl chloride is being transported in MC-330 transports, but only in a few isolated cases and usually in a cargo tank truck owned by the user of the product.

Anhydrous ammonia is unloaded from cargo tank trucks by a compressor or liquid pump; LP-gas by a compressor or liquid pump; and methyl chloride and sulfur dioxide by a compressor. Liquefied fluorinated hydrocarbons are usually unloaded from cargo tank trucks by a turbine pump although you can use a compressor. ICC regulations for unloading cargo tank trucks (page 87) and precautions stated on page 88 are to be taken.

Procedures are generally those described in unloading single-unit tankcars. Even where responsibility for unloading cargo tank trucks rests with the carrier or transport owner, you (the consignee) should be familiar with the entire unloading procedure so that it's as well known to you as to the transport's operator in charge of the transfer.

2—Problems With Specific Gases

Anhydrous Ammonia

Anhydrous ammonia is classified by the ICC as a nonflammable gas.

In transferring ammonia from containers, including single-unit tankcars, TMU containers and cargo tank trucks, never use compressed air as it will contaminate ammonia.

The continuous presence of the sharp, irritating odor of ammonia is evidence of a leak. You can pinpoint leaks in ammonia valve connections or feed lines by allowing fumes from an open bottle or hydrochloric acid (or from a squeeze bottle of sulfuric acid, or from a sulfur dioxide aerosol container) to come in contact with ammonia vapor. This produces a dense fog. Leaks may also be detected with moist phenolphthalein or litmus paper. Sulfur tapers for detecting ammonia leaks are not recommended.

When there is a leak around an ammonia container valve stem, you can usually correct it by tightening the packing gland nut which has a left-hand thread.

When a leak occurs in a congested area where atmospheric dissipation is not feasible, absorb the ammonia in water. Its high solubility in water may be utilized to control escape of ammonia vapor. Applying a large volume of water from a fog or spray nozzle lessens vaporization as the vapor pressure of ammonia in water is much less than that of liquid ammonia.

Don't neutralize liquid ammonia with acid—heat generated by the reaction may increase the fumes.

Only an authorized person should attempt to stop a leak, and if there is any question as to the seriousness of the leak, a gas mask of the type approved by the U. S. Bureau of Mines for use with ammonia must be worn. Have all persons not equipped with such masks leave the affected area until the leak is stopped.

Also, provide personnel subject to exposure to ammonia with a hat, gloves, suit and boots, all garments of rubber. Garments worn beneath rubber outer clothing should be of cotton. Some protection to the skin may be obtained by applying protecting oils before exposure to ammonia. Supply approved eye goggles if the eyes aren't protected by a full face mask.

Although ammonia is flammable only within the narrow limits of 16 to 25% by volume, the mixture of oil with ammonia broadens this range. Therefore, take every precaution to keep sources of flame or sparks from areas that have ammonia storage or use.

In the event a fire does break out in an area containing ammonia, make every effort to remove portable containers from the premises. If they cannot be removed, inform the firemen of their location.

For data concerning the physiological effects of ammonia, protective equipment and first aid measures, obtain a copy of "Pamphlet G-2, Anhydrous Ammonia" published by the Compressed Gas Association, Inc.[8]

L-P Gases

All LP-gases are classified by the ICC as flammable gases and must be treated as such. Obtain a copy of the National Fire Protection Association "Pamphlet 58, Standard for the Storage and Handling of Liquefied Petroleum Gases."[4]

Liquid LP-gas leaks in transfer piping are indicated by frost at the point of leakage due to the low boiling point of the material.

You can detect extremely small leaks and leaks in vapor transfer piping by applying soap suds or a similar material to the suspected area.

Under no circumstances should you use a flame to detect a leak.

The most important safety considerations in unloading LP-gas are: avoid unnecessary release of the product; keep any open flames and other sources of ignition away from the unloading area; and make sure suitable first-aid type fire extinguishers are available (dry chemical or carbon dioxide types are suitable for LP-gas fires).

It's important for personnel to be familiar with the characteristics of LP-gas. You must realize the importance of not extinguishing a fire unless by doing so you stop the source of the leakage (as by closing a valve). This is so because if you extinguish the fire and leakage is allowed to continue, unburned vapor could accumulate and possibly result in a more serious hazard than if you allowed the fire to burn.

If a fire is in progress and an LP-gas storage tank is exposed, it is of prime importance to keep the container cool by applying hose streams of water until the fire is properly extinguished. By the same token, if fire threatens a single-unit tankcar, a TMU car or a cargo transport truck, immediately remove these from the area. If this isn't possible, apply hose streams of water, as in protecting storage tanks.

▶ **Unloading From Tankcars**—If unloading LP-gas from single-unit tankcars with a compressor and vapors are being recovered from the tankcar's tank, stop the compressor and close all vapor lines when the tankcar vapor pressure is reduced to about 15 psig. Bleed the vapor lines along with already closed liquid lines and replace all plugs in tankcar valve opening and transfer hoses.

To unload by gas or air repressure, after the plugs are removed from the tankcar liquid eduction valves:

- Connect the unloading hose and storage assembly line which may be a riser, or part of the storage tank manhole assembly.
- Connect the repressuring hose assembly.
- Connect the representing hose assembly to the tankcar vapor valve and to the compressed air (or gas) supply line. This line *must* have a check valve and an atmospheric vent.
- Open the tankcar liquid eduction valves slowly but completely.
- If an unloading riser is used, then slowly open the liquid line valve.

Chlorine

In both its liquid and gaseous form, chlorine is neither flammable nor explosive. It is classified as a nonflammable compressed gas by the ICC. Its principal hazard arises from inhalation from leaks. For data describing its physiological effects, handling, employee training and protection, and its chemical characteristics and physical properties, obtain a copy of the Chlorine Institute's manual.[5]

Also, consult with your chlorine manufacturer concerning these matters, as well as the equipment required for handling chlorine, specifications and maintenance of the equipment and the special safety precautions and safety equipment required.

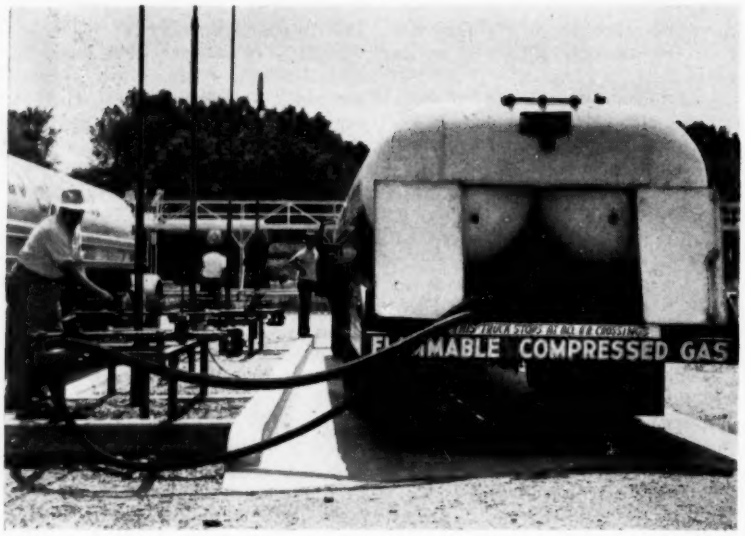
All chlorine containers, including single-unit tankcars, are intended for use by you (the customer) to deliver chlorine direct to process. Thus, differing from the other liquefied compressed gases, there is no need for intermediate storage tanks between the shipping container and the process. Moreover, the use of chlorine storage tanks between the container and process is frequently hazardous.

Usually, chlorine tankcars are filled at low temperature and pressure. Normally, the inherent pressure of the vapor in the tankcar is sufficient to accomplish withdrawal of liquid chlorine to process, but sometimes, especially during the winter, the car is air-padded to accomplish liquid withdrawal.

In Fig. 4 is shown a typical arrangement for unloading liquid chlorine from tankcars Liquid flow is through the tankcar's liquid eduction valve to a liquid evaporator within your battery limits and then

In Unloading Tankcars, Insist Personnel Follow These Rules

- **Never introduce a compressed gas into a tankcar or container of any kind that holds or has held another compressed gas or chemical.**
- **Never introduce water or another material into a tankcar or any other compressed gas container.**
- **Don't remove tankcar valves—under any conditions.**
- **Never hammer tankcar fittings in an attempt to open excess flow check valves, nor for any other reason.**
- **Never enter empty tankcars for any purpose whatsoever.**
- **Don't attempt to correct leaks at unions, or other fittings in a line, with a wrench while the line is under pressure.**
- **Never fill your storage tank full; the consequences are very serious. Observe readings on gaging devices and fill only to allowable maximum level.**
- **Where compressor, pump or piping, handling a heavier-than-air compressed gas, is located in a trench or pit, caution the operator to check these low spots for vapors since they can occupy an enclosure or trench by displacing the air.**
- **When all unloading connections seem to be tight, pressurize the system and check for any leaks.**
- **Never break a hose coupling under pressure.**



TANK TRUCK for LP-gas service, above, contains its own unloading equipment.

direct to process. Whenever liquid chlorine can be trapped between two valves, you must protect the line by a heated expansion chamber.

When air-padding is required, introduce only clean, oil-free, cooled, dry compressed air into the tankcar through its vapor valve.

▶ **Absorbing Chlorine in a Liquid**—If chlorine is to be absorbed in a liquid, there is a tendency for the liquid to suck back into the container when the container becomes empty due to the creation of a partial vacuum. Avoid this as it has resulted in numerous accidents.

As soon as the container is empty and its pressure has dropped to zero, shut the container valve. Then, vent air into the line leading from the container, after the valve has been shut off to prevent liquid from "sucking back" into the line. For this purpose, install a "vacuum break" valve or loop on the chlorinator well line.

▶ **Rules for Unloading**—In general, rules for unloading all chlorine containers apply to the tankcar operation. These include:

Safety devices must never be tampered with.

Open container valves slowly.

Make sure that threaded connections are the same as those on the container valve outlets. Never force connections that don't fit. The outlet threads on valves of TMU containers are not tapered pipe threads.

Containers or valves should never be altered or repaired by you.

Gas leaks around the valve stem may usually be checked by tightening the packing nut.

Test for chlorine leaks by attaching a cloth to one end of a stick, soak the cloth with strong ammonia-water, and apply to the suspected area. A white cloud of ammonium chloride results if there is any chlorine gas leakage. Don't use the usual household ammonia—it isn't strong enough.

Use only reducing valves and gages designed for chlorine. Consult your chlorine producer for details.

In addition to complying with ICC regulations governing unloading tankcars, the following special rules are recommended where you are handling chlorine in tankcar quantities:

Switch-tracks on which chlorine tankcars are placed for unloading should be devoted solely to this purpose.

When chlorine tankcars are located on a dead-end siding, protect the cars on the switch end by a locked derail; if on an open-end siding, at both ends. Keys should be in charge of a designated responsible person.

Unloading single-unit chlorine tankcars should be done through flexible metal connections that compensate for the vertical rise of the tankcar as its springs decompress during unloading. For all details relating to the unloading line, consult the chlorine producer. However, don't depend upon flexible connections as a safety factor in case of a bump by switching operations during unloading.

Place derails as stated previously and use a blue lantern, suitably placed, if unloading at night.

Perform unloading, connecting and disconnecting operations only in well-lighted places by reliable persons who are properly instructed, responsible for operations and equipped with chlorine gas masks.

In shutting off the flow of liquid chlorine, be careful not to leave the line full of liquid chlorine with valves closed at both ends. Otherwise the liquid remaining in the line may warm up and the resulting expansion of the liquid burst the pipeline by the hydrostatic pressure thus developed.

Close the tankcar valve first and then allow the discharge line to empty by continuing to use the chlorine remaining in the line. After this, close both ends of the line.

Never apply heat directly to tankcars. It may, however, be desirable in some locations subject to low winter temperatures, to unload the tankcars in a shed maintained at 70-75 F.

In certain cases, particularly in winter weather with its low outside temperature, the pressure in single-unit cars may not be adequate and it's then necessary to increase it by adding dried compressed air to secure the desired rate of discharge.

Use only thoroughly dried clean air for this purpose. Have clean air supplied by a separate air compressor used only for this service. Never connect an existing compressed air system to the chlorine tankcar.

The air dryer must be of suitable capacity to supply the full requirements. It must be maintained in proper operating condition. Consult the chlorine producer for all details relating to the application of dry air to single-unit tankcars. You can also obtain a specification for adding dry air to single-unit tankcars from the Chlorine Institute, Inc.

If you are using the chlorine at an elevation substantially above that of the tankcar, high pressure is required in the car to force the liquid to that higher elevation. It's much safer to locate a chlorine evaporator at the elevation of the tankcar and pipe the gaseous chlorine to the higher elevation.

With single-unit tankcars used for all other liquefied compressed gases, the content is withdrawn to storage. It's desirable to unload them as quickly as possible and at a rate consistent with good practice by connecting both liquid eduction valves to the transfer lines. However, the rate of withdrawal of liquid chlorine from tankcars is governed by the requirements of the process and withdrawal may not be continuous. Accordingly, it may be desirable to unload through only one liquid valve. Open this valve, as is the case when two are used, slowly but completely.

When air-padding is necessary, connection of the compressed air line is made to one or both vapor valves. When a tankcar has been "padded" with air, the pressure may become excessively high if the car is allowed the warm up when no chlorine is being withdrawn. Consequently, check the tankcar pressure periodically during prolonged shutdowns so that excessive pressure may be vented carefully into caustic soda solution or into milk of lime in a large tank before the safety valve releases.

You can withdraw chlorine in gaseous form by unloading through the vapor valve or valves. However, this procedure is quite unusual.

The pipe connected to a tankcar discharge line should be no longer than 18 in. and should be screwed in with a pipe wrench not larger than an 18-in. size. Use of longer connecting lines and larger wrenches may result in tilting the tankcar valve on its gasket causing a chlorine leak.

Extra-heavy black iron or steel pipe is recommended for chlorine service. All threads should be clean and sharp, preferably cut with new dies.

If night operations are necessary, adequately light the area where the tankcar is hooked up.

▶ **Gas Masks**—Canister gas masks of a type approved by the U. S. Bureau of Mines for chlorine service should always be readily available when chlorine is unloaded, stored, transported or used. Locate gas masks outside the probable area of contamination so that it's possible to reach them in case of emergency.

Canister-type gas masks don't supply oxygen; they absorb the chlorine content present in the air leaving clean air to breathe. Where the chlorine content is greater than 1%, use a self-contained oxygen breathing apparatus or fresh air hose mask. Each chlorine consumer should have at least one such device available in his plant. All personnel who may be required to use gas masks should be properly instructed in their application and use. Obtain a copy of National Safety Council Pamphlet No. 64, "Respiratory Protective Equipment."[6]

A poor gas mask is worse than no gas mask at all. Since the active materials in a canister become inactive when exposed to chlorine or air, keep canisters sealed. Renew them after each use.

▶ **Emergency Measures**—In an emergency, telephone your chlorine manufacturer.

In case of fire, remove chlorine containers from the fire zone immediately.

As soon as there is any indication of the presence of chlorine in the air, take steps to correct the condition. Chlorine leaks never get better; they always get worse if not corrected promptly.

Keep on the windward side of the leak and higher than the leak. Since gaseous chlorine is approximately two and one-half times as heavy as air, it tends to lie close to the ground.

When a chlorine leak occurs, authorized, trained personnel equipped with gas masks should investigate. All other persons should be kept away from the affected area until cause of the leak is discovered and corrected. If the leak is extensive, warn all persons in the path of the fumes.

Don't spray water on a chlorine leak. To do so makes the leak worse because of the corrosive action of wet chlorine. Heat supplied by even cold water causes liquid chlorine to change to gas at a faster rate.

When a leak occurs in equipment in which chlorine is being used, immediately close the chlorine container valve.

If a chlorine container is leaking in such a position that chlorine is escaping as a liquid, turn the container so that chlorine gas escapes. The quantity of chlorine escaping from a gas leak is about one-fifteenth the amount that escapes from a liquid leak through the same size hole.

If a chlorine leak occurs in transit in a congested area, it is recommended that the vehicle keep moving, if possible, until it reaches an open area where the escaping gas will be less hazardous. If a chlorine leak occurs in transit and the conveying vehicle is wrecked, the container or containers should be shifted so that gaseous chlorine, rather than liquid, is escaping. If possible, transfer the containers to a suitable vehicle and take it to open country.

Leaks at valve stems are often stopped by tightening the valve packing nuts or closing the valve.

You can lessen the severity of a chlorine leak by reducing the pressure on the leaking container. This may be done by absorbing chlorine gas, from the container, in caustic soda solution or milk of lime. Evaporation of some of the liquid chlorine cools the remaining liquid, reducing its pressure.

At regular points of storage and use, make emergency preparations for disposing of chlorine from leaking cylinders or ton containers. Chlorine may be absorbed in caustic soda, soda ash or hydrated lime solution. Caustic soda solution is preferred as it absorbs chlorine most readily.

A suitable container to hold the solution should be provided in a convenient location. Chlorine may be passed into the solution through an iron pipe or rubber hose properly weighted to hold it under the surface. Don't immerse the container in the solution.

Methyl Chloride

Methyl chloride is classified as a flammable gas. It burns feebly but forms explosive mixtures with air. The end product of high-temperature decomposition may be toxic. For data concerning the chemical and physical properties of methyl chloride, its physiological effects, protective equipment, etc., obtain a copy of the "Methyl Chloride Data Sheet"[7] published by the Manufacturing Chemist's Association, Inc.

Throughout the entire single-unit tankcar unloading operation, particularly while connecting and disconnecting, take great caution to make sure the working area is free of heated surfaces, flames, static electricity, railroad locomotives, gasoline tractors and all other sources of ignition. Tankcars and TMU containers should be grounded electrically.

Under no circumstances should you introduce water or other materials into tankcars which contain, or have contained methyl chloride.

In testing for leaks, use soapy water; in freezing weather or around very cold pipes or equipment, use glycerine. Never test for leaks with an open flame. This is prohibited and it applies not only to tankcars but to all containers holding methyl chloride.

When unloading single-unit tankcars after all of the liquid has been transferred, the greater part (but not all) of the methyl chloride vapors may be recovered by creating a slight pressure differential. Observe caution in this operation as a slight residual pressure must always remain on the tankcar so that no air is drawn into it to form explosive mixtures when the pipes are disconnected.

When unloading tankcars, if a leak occurs which cannot be readily repaired by simple adjustment or tightening of the fittings, telephone your methyl chloride manufacturer at once for instructions and evacuate the area around the car immediately. Permit only properly protected and instructed personnel to enter the contaminated area.

In case of TMU container leaks, all sources of ignition must be removed from the area at once, and if the leak cannot be stopped, transfer the methyl chloride to another container. As to the procedure, obtain and follow the detailed instructions of your methyl chloride manufacturer.

▶ **Fire and Explosion Hazards**—Avoid all sources of ignition, of whatever nature, when unloading single-unit tankcars and TMU containers holding methyl chloride.

Methyl chloride fires are gas fires. Most effective method of extinguishing them is to shut off the flow of vapor by closing the valves.

Carbon dioxide or dry chemical may be used to extinguish the flame to permit access to shut-off valves. If the valve is in the area of the fire, attack it if possible, close it, and then attack and extinguish the secondary fire which consists of other burning material ignited by the gas fire.

Circumstances may make it impossible to attack the valve, and in such a case, the flame may be allowed to continue burning while the surrounding area and objects are cooled with water spray.

Provide employees engaged in extinguishing fires with gas masks to protect them from methyl chloride vapors and the toxic combustion products formed.

Sulfur Dioxide

Sulfur dioxide is classified by the ICC as a nonflammable gas. In both its gaseous and liquid form it is neither flammable nor explosive. It is a respiratory and a skin and eye irritant. Obtain a copy of the "Sulfur Dioxide" pamphlet published by the Compressed Gas Association, Inc.[8] for data concerning its chemical and physical properties, physiological effects, protective equipment, etc.

The pressure differential necessary to unload sulfur dioxide from a single-unit tankcar into a storage tank may be controlled in several ways. In some instances it's only necessary to release the pressure on the storage tank by actually using sulfur dioxide from the storage tank in the regular way while unloading the tankcar.

Where you have two or more storage tanks, you may unload the car by building the pressure up in one of the storage tanks to 25 or 30 psi. higher than the pressure in the tank to be filled. This higher pressure is then applied to the tankcar to force the liquid into the storage tank.

Probably the best method of unloading a single-unit tanker is by installing a compressor with the suction side connected to the top of the storage tank and the discharge side connected to one of the gas valves of the tankcar.

Least desirable method of unloading is to apply air pressure to the tankcar through the vapor valve. If this method is used, exercise great care to insure that the supply of air is clean and dry and at a sufficiently high pressure to prevent back flow of sulfur dioxide into the air line.

▶ **Feeding SO_2 Into a Solution**—Where it is desirable to feed sulfur dioxide gas into a solution, the pipe leading from the valve on the container will frost on the outside and may even cause the solution to freeze at the point where the sulfur dioxide is being absorbed. If this happens you may correct the trouble by steam jacketing a small section of the feed line.

When gas is being fed to a solution, the evaporation of the liquid in the container refrigerates the entire content. As a result, the pressure might be reduced to a point where there's little or no flow of gas. In this case it is necessary to apply heat to the container or to connect a number of containers in parallel. This retards the rate of evaporation in each one.

Because of the corrosive nature of sulfurous acid, exercise great care to prevent the solution from drawing back into the upper valve chambers when the feed valve is shut off at the container or storage tank. To prevent this from happening it is imperative that the feed line is vented or that a stainless steel ball check or check valve is installed in the line.

▶ **Leaks**—The occurrence of sulfur dioxide leaks are indicated by the pungent odor of the gas. Locate by using a wad of cloth soaked in ammonium hydroxide. This produces white fumes near the point of the leak.

Leaks which might develop are ordinarily not serious and can be readily controlled. Where leaks do occur, shut off the supply of sulfur dioxide by closing the appropriate valve. Leaks at unions or other fittings are often eliminated by tightening the connection.

Do not work on a line while it is under pressure. If corrosion is indicated, take care to empty the lines before working on them. A broken fitting might lead to a serious loss of sulfur dioxide before the supply valves can be shut off.

Although serious leaks rarely occur, careless handling sometimes results in this condition. Tankcar and TMU container valves are made of brass and if struck by a heavy object, may be broken.

Leaks may also occur from carelessness in heating TMU containers, causing the fusible plug to melt and discharge the contents. Care in handling eliminates those dangers. Occasionally, leaks may develop in the

valve packing, but you can check these by tightening the packing nut.

In the event of a leaking container, wherever possible, move the container to an open area where the hazard due to escaping sulfur dioxide is minimized.

If a container is discharging too freely to permit movement, it should, if possible, be arranged in such a position that the leak is at the top, thus discharging gaseous sulfur dioxide and not liquid.

If large quantities of gas can be withdrawn rapidly into equipment, or satisfactorily vented, the evaporation often lowers the pressure in the container to such a point that you can move it to the open without difficulty; or, possibly, the leak can be repaired by persons provided with suitable masks.

If the leak still prevents removing the container to an open area, gaseous or liquid sulfur dioxide can be vented into a solution of lime, caustic soda or other alkaline material. One lb. of sulfur dioxide is equivalent to about 2 lb. of lime or 1½ lb. of caustic soda.

When a leak does occur, only an authorized employee should attempt to stop it, and if there is any question as to the seriousness of a leak, a suitable gas mask should be worn. In general, where leaks are serious, the employee, even when equipped with a suitable gas mask, should remain in the contaminated area only long enough to make emergency adjustments.

▶ **Provisions for an Emergency**—All employees handling sulfur dioxide should be impressed with the potential danger it represents and should be trained in its safe handling. In addition, provide them with personal protective equipment for use in an emergency and drill them until they are familiar with its use.

This protective equipment should include a gas mask of a type approved by the Bureau of Mines for sulfur dioxide service. Take care to assure that masks are kept in proper working order and that they are stored so as to be readily available in case of need.

Canister-type masks are unsafe for high concentrations of sulfur dioxide. Warn your employees of possible failure of this type of mask in the event of a really serious leak. Self-contained oxygen breathing apparatus or a mask with a long air hose and outside source of air may be required under extreme conditions.

Other protective equipment provided should include goggles or large-lensed spectacles to eliminate the possibility of liquid sulfur dioxide coming in contact with the eyes and causing possible injury.

If sulfur dioxide should be released, the irritating effect of the gas will force personnel to leave the area before they have long been exposed to dangerous concentrations. To facilitate their rapid evacuation, provide sufficient, well-marked, easily accessible exits.

Since sulfur dioxide neither burns nor supports combustion, there's no danger of fire or explosion due to igniting gas or liquid.

If a fire breaks out due to some other cause in an area containing sulfur dioxide, make every effort to remove the containers from the area to prevent overheating which would lead to melting of the fuse plugs. If they cannot be removed, inform the firemen of their location.

Fluorocarbons

Liquefied fluorinated hydrocarbons are classified as nonflammable gases by the ICC. Those presently shipped in single-unit tank-cars, TMU containers and cargo tank trucks are: dichlorodifluoromethane, trichloromonofluoromethane, monochlorodifluoromethane, dichlorotetrafluoromethane and trichlorotrifluoromethane.

These gases are odorless and leaks can't be detected by sense of smell. Frosting is evidence of a large leak while smaller leaks may be located by means of a halide torch.

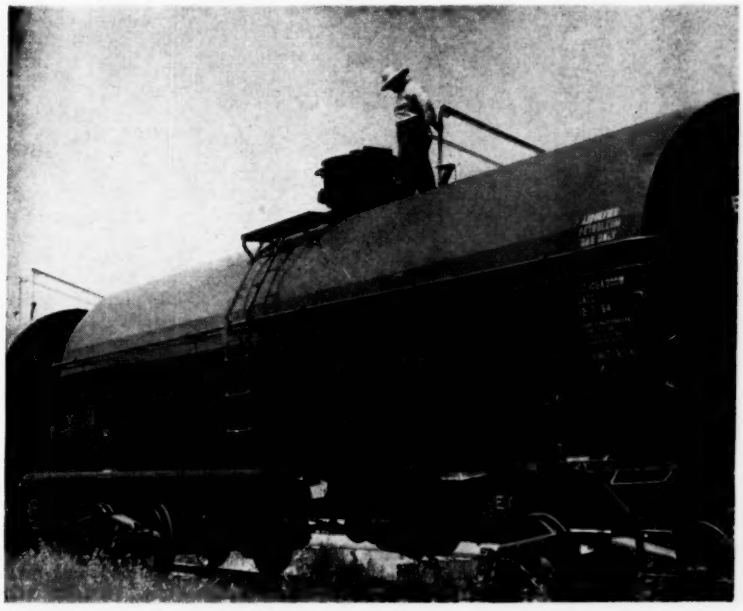
Avoid contact with the liquid and excessive inhalation of vapor. In case of a severe leak, persons entering area of dense concentration of vapor should wear an air gas mask of the type approved by the U. S. Bureau of Mines for liquefied fluorinated hydrocarbon service.

Check the Bible

ICC regulations, and such local regulations as may exist in your area as well as industry standards are the "Bible" for handling and unloading compressed gas. Statements made herein are intended only to complement these regulations and not to supplant them.

Obviously, within the limits of this article, it isn't possible to set

SELECTION of unloading personnel should be done with great care.



forth all the precautions to be taken when handling and unloading a particular gas. It is possible only to mention some of the more important. In all cases, your compressed gas manufacturer must be consulted concerning your specific handling and transfer problems, and he will advise you in full concerning them.

Acknowledgments

A special committee to prepare this article was appointed by the Executive Board of Compressed Gas Association, Inc. The committee consists of D. J. Barday, "Freon" Products Division, E. I. du Pont de Nemours & Co., Inc.; F. J. Heller, Phillips Petroleum Co.; E. C. Perrine, Nitrogen Division, Allied Chemical Corp.; James S. Walker, Hooker Chemical Corp.; George T. Wrenn, Jr., Virginia Smelting Co., and F. R. Fetherston, Compressed Gas Association, Inc., who acted as chairman and whose name appears in the byline. The chairman acknowledges the contributions and efforts of each committee member in the preparation of this article.

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Chairman

FRANKLIN K. FETHERSTON is Secretary-Treasurer of the Compressed Gas Association, a post he has held since 1927. A graduate engineer from Carnegie Tech, Fetherston served in both World Wars' I and II. He is a Director of the National Fire Protection Association and, in that organization, now serves as Chairman of the Gases Field Service Committee and the Executive Committee of the Committee on Gases. His interests have taken him to many parts of the world and since 1949 he has represented the ASA and the Canadian Standards Association on the International Organization for Standardization.

This Report Was Prepared by a Special Committee of the Compressed Gas Association

D. J. BARDAY has been with duPont's "Freon" Products Div. as a refrigeration engineer and technical assistant since 1955. He is currently assigned to the "Freon" Products Laboratory. Barday is a graduate from the U. of Colorado with a BS in ME.

F. J. HELLER, employed by Phillips Petroleum, is a graduate chemical engineer from the U. of Oklahoma and a registered professional engineer. He is chairman of the CGA's Safety Device Committee and vice chairman of its General Technical Committee.

E. C. PERRINE is Technical Service Representative with the Barrett and Nitrogen Div. of Allied Chem. Corp. specializing in ammonia and ammonia solutions. A Michigan State graduate, Perrine has experience in construction and operation of gas plants.

J. S. WALKER is currently Manager of Technical Service with Hooker Chemical Corp. He has been with them, in various capacities in production and sales, since graduating from Union College. Walker received a Bachelor of Science degree in chemistry in 1940.

G. T. WRENN, JR. is vice president of Virginia Smelting Co. He graduated in 1937 from Virginia Polytech with a BA in Mechanical Engineering and is a registered professional engineer. Wrenn is on the executive board of the Compressed Gas Association.

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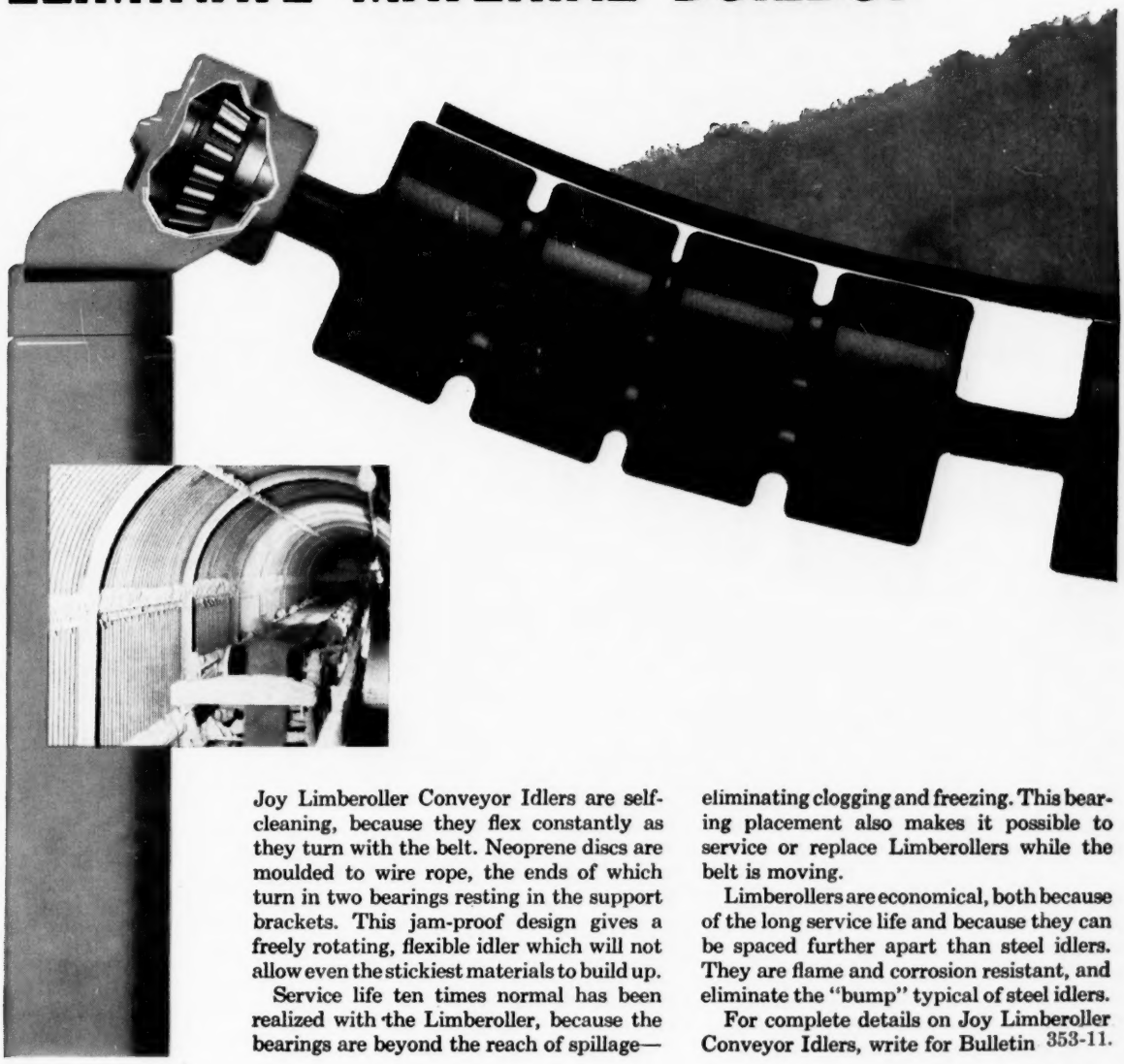
SELF-CLEANING JOY LIMBEROLLER® CONVEYOR IDLERS ELIMINATE MATERIAL BUILDUP



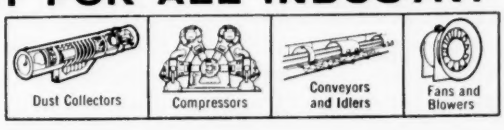
Joy Limberoller Conveyor Idlers are self-cleaning, because they flex constantly as they turn with the belt. Neoprene discs are moulded to wire rope, the ends of which turn in two bearings resting in the support brackets. This jam-proof design gives a freely rotating, flexible idler which will not allow even the stickiest materials to build up.

Service life ten times normal has been realized with the Limberoller, because the bearings are beyond the reach of spillage—eliminating clogging and freezing. This bearing placement also makes it possible to service or replace Limberollers while the belt is moving.

Limberollers are economical, both because of the long service life and because they can be spaced further apart than steel idlers. They are flame and corrosion resistant, and eliminate the "bump" typical of steel idlers.

For complete details on Joy Limberoller Conveyor Idlers, write for Bulletin 353-11.

EQUIPMENT FOR ALL INDUSTRY



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Joy Manufacturing Company
Oliver Building, Pittsburgh 22, Pa.

In Canada: Joy Manufacturing Company (Canada) Limited, Galt, Ontario

CE COST FILE

No. 17: Labor Factors; Structural Steel

William G. Clark, Dow Chemical Co., Pittsburg, Calif.

Compute Labor Needs for Structural Steel

The information in this Cost File is from a handbook for training engineers in maintenance cost estimating. Use of labor factors makes it possible to apply local wage rates to these tasks.

One method of estimating fabrication and erection labor requirements for structural steel is to use two factors based on pounds of steel involved—one to cover fabrication and the other erection. The per pound method requires careful consideration of the circumstances at hand and adjustment of labor factors to meet the conditions.

The following table gives the average number of man-hours per 100 lb. for fabrication and erection of structural steel.

Weight, lb.	Man-hr./100 lb. Fabrication	Erection
0-100	4.6	5.0
101-300	3.5	5.0
301-700	3.5	3.75
701-1,500	2.2	3.0
1,501-up	1.5	3.0

The labor factors in the table are based on (1) shop fabrication with maximum use of labor saving machinery; (2) field erection with crane or similar equipment.

These factors should be adjusted up or down to cover unusual conditions such as field fabrication, difficult rigging, etc. Most jobs have major areas that fit into a normal category; adjustments for unusual conditions should be applied only to the affected areas.

Stairs

Steel stairs are generally made by placing a steel tread between a pair of 10 in.-15.3 lb. channels. Tread has a width of 10 in., and the recommended rise between treads is 7½ in. It's common practice to limit the number of treads between platforms to 17. This factor should not be overlooked; runs greater than 17 will require insertion of platforms which will increase the cost of a project.

Calculate the labor requirement for stair fabrication (cutting the stringers and attaching the treads only) at 2 man-hours per tread. Erection of stairs is a relatively simple operation, but because of weight and bulk it usually requires rigging personnel and equipment. If the location is reasonably accessible, a 3-man rigging crew should be able to move the stairs from the fabrication site and install in 2-3 crew hours.

Hand-railing

Hand-railing is made up of two horizontal rails of 1¼ in. dia. pipe, 1¼ in. dia. vertical posts on 6-8 ft. centers and a ½ in. × 6 in. continuous toe plate.

Fabrication and erection of hand-railing, including a reasonable number of bends and stair railing, should take 0.50 to 0.75 man-hours per lineal foot. On long straight runs, not complicated by turns or stairs, the labor drops to 0.30 to 0.50 man-hours per lineal foot.

Floor Plate

Diamond-pattern ¼ in. steel floor plate spans 4 ft. 0 in. without intermediate support and is available in 4 ft. 0 in. × 10 ft. 0 in. sheets. Joints are continuously welded and plates are tack welded, usually on 6 in. centers, to the supporting structure.

Floor plate in sizes 4 ft. 0 in. × 4 ft. 0 in. to 4 ft. 0 in. × 10 ft. 0 in. can be installed at the rate of 6-8 sq. ft. per hour. If there is considerable cutting and fitting to be done, the rate should be decreased to 3-5 sq. ft. per hour.

It is often necessary to provide pipe openings with drip collars in floors. Openings and collars for lines up to 4 in. dia. require approximately 2 man-hours, and for lines 6-10 in. dia. approximately 4 man-hours.

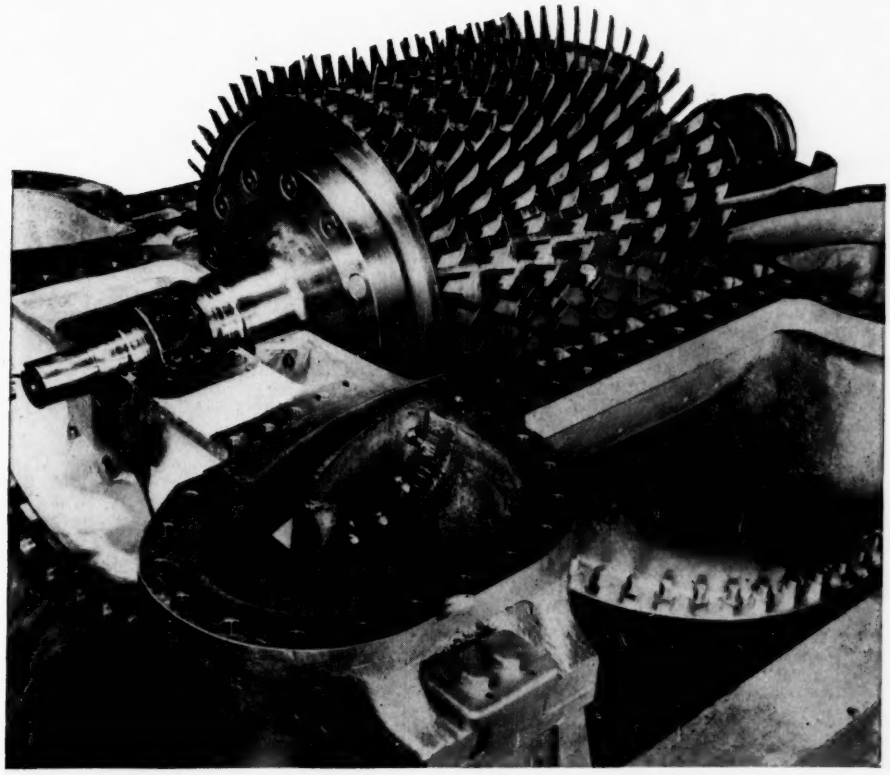
Ladders

Standard pipe ladders without guard edge require approximately 1.5 man-hours per lineal foot to fabricate. Ladders with a cage require 2.25 to 2.5 man-hours per lineal foot. Erection of a ladder is a variable item depending on ladder height. A minimum of 4 man-hours to a maximum of 16 man-hours should cover a range of ladders from 6 ft. 0 in. to 20 ft. 0 in.

Let Us Hear From You

Send your cost data, preferably in tabular or graphical form and with a minimum of text, to CE Cost File Editor, Chemical Engineering, 330 W. 42nd St., New York 36, N. Y. Any legible form is acceptable. We will pay regular department space rates for all the material published in Cost File.

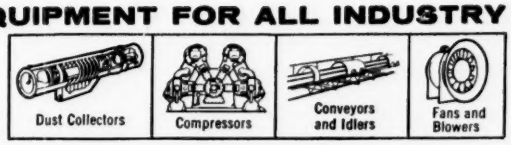
HIGHER STAGE PERFORMANCE
OF JOY DYNAMIC COMPRESSORS MEANS LOW COST AIR



The higher stage performance of Joy Centrifugal and Axial Compressors can save you money by reducing the cost of your plant and process air. Because of higher efficiency, Joy compressors can provide the air you need with fewer stages. This means fewer parts, fewer inter-stage seals, shorter and more rigid rotors, lower bearing loads, and many other design features which reduce both the installed cost and the maintenance cost of the machines.

Joy dynamic compressors can be supplied in sizes from 15 to 15,000 hp, and can be designed for any class of service from furnishing plant air to compressing hot process gases. Whatever the air or gas compressing problem, you can be certain that a Joy dynamic compressor will be the most efficient solution. For complete information, write for Bulletin 348-11.

AIR MOVING EQUIPMENT FOR ALL INDUSTRY



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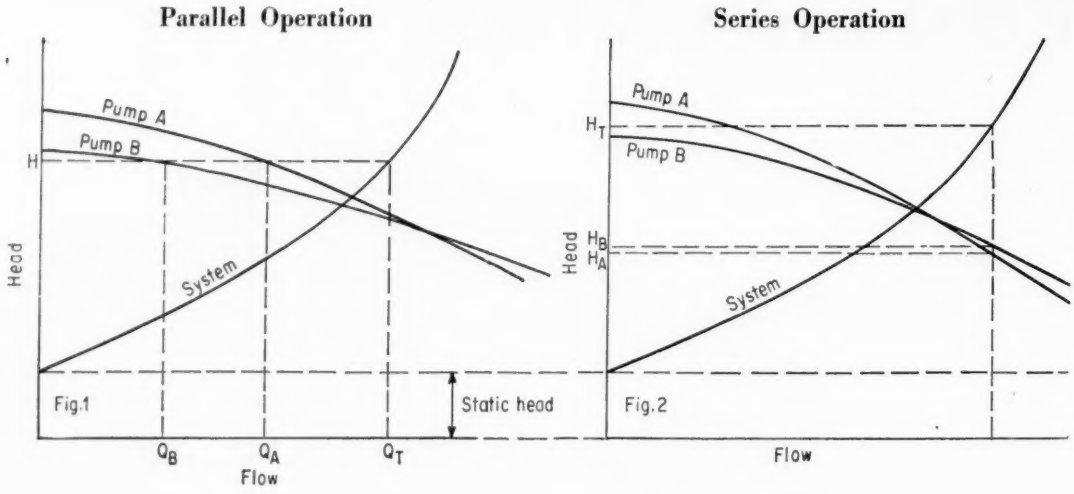


Solve Multiple Pump Hookups Graphically

If you have characteristic curves for the pumps and the system, you can easily find the necessary operating conditions without calculation.

Theodore Diskind
Department of Chemical Engineering, Engineering Research Laboratories, Columbia University, N. Y., N. Y.

Recently we were discussing multiple-pump systems and the analytical, trial-and-error method by which they are usually solved. It is not generally known that there is a much easier graphical method.

This method, illustrated above, can be used with pumps having the same or different characteristics. Plot the pump characteristic curves along with the system characteristic on the same piece of paper and proceed as described below.

Parallel Operation, Fig. 1—In parallel operation the head developed by each pump must be the same as the system head. Therefore, draw a series of horizontal lines (constant head), intersecting the three curves. The line representing stable operation is the one on which system flow Q_t is exactly equal to the sum of the flows of the individual pumps, $Q_a + Q_b$. If the pumps are identical, of course, $Q_a = Q_b$ and $Q_t = 2\ Q_a$.

Series Operation, Fig. 2—In series flow the heads can differ but the pump capacities and the system capacity must all be equal. Therefore, draw a series of vertical lines (constant flow) until you find one on which the system head H_t is equal to the sum of the pump heads $H_a + H_b$.

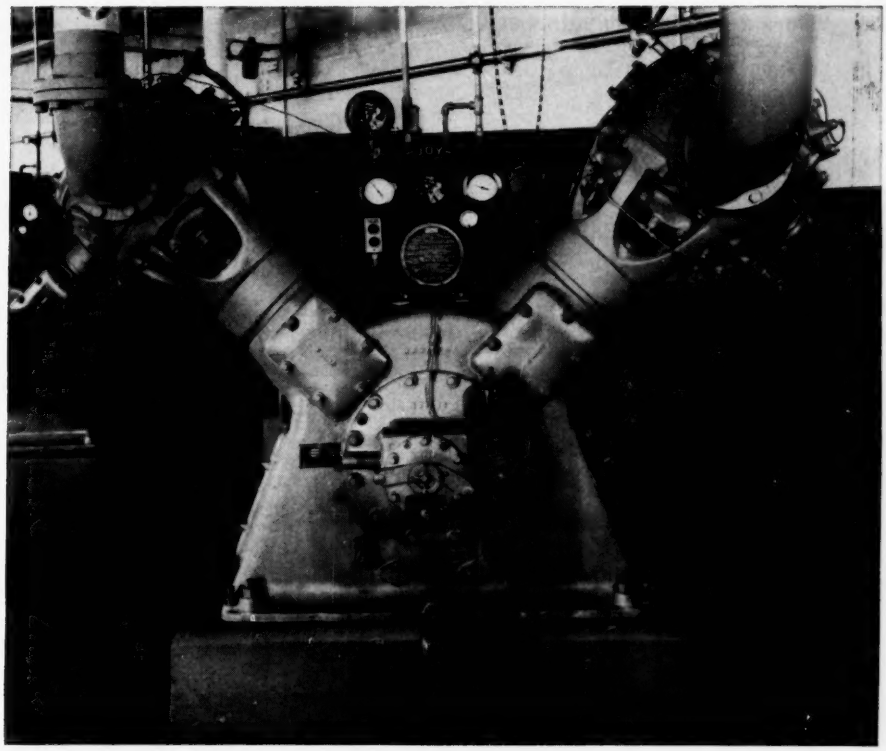
Simple Way to Find Washing Endpoints

P. Almandoz Madan
Senior Processing Engineer
Nickel Processing Corp.
Nicaro, Oriente, Cuba.

When titrations have to be performed by operators without chemical training, it is usually worthwhile to make the method as simple and foolproof as possible.

For example, we have an operation in which we water-wash out the residual ammoniacal liquor from a cake retained on a Sweetland filter. We find that the economic limit for the wash-

MAINTENANCE-FREE JOY COMPRESSORS PROVIDE LOW COST PLANT AND PROCESS AIR

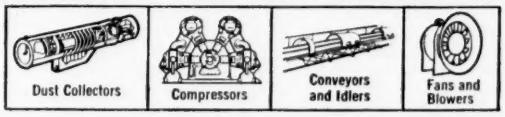


The cost of your plant and process air depends both upon the installed cost of the compressor and the cost of maintenance necessary to keep it operating. Joy compressors offer savings in both areas.

Installed cost of Joy compressors is lower because of the space-saving design. However, the big savings are realized in the low maintenance required for Joy compressors—particularly in the oil-free types. For example, the compressor above has the exclusive T-block design piston rings that last twice as long by automatically compensating for wear. As for valves, which normally require inspection and maintenance, Joy designers have made them readily accessible and secured by only three well-positioned bolts.

Joy reciprocating compressors are available in a wide range of sizes for both oil-free and plant air service. For complete information on how Joy compressors can save you money on air, write for Bulletin 349-11.

AIR MOVING EQUIPMENT FOR ALL INDUSTRY



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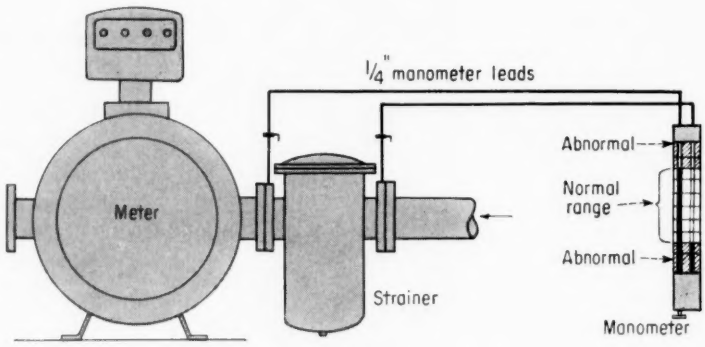
ing is at an ammonia content of 0.23 gram/100 cc. in the washings. It is necessary to be able to test the washings for completion in a matter of seconds so that titration with the usual laboratory equipment would not be feasible.

The method we selected is to test a fixed volume of the washings with a fixed volume of a standard acid solution, using an indicator which will show whether the endpoint has been reached, has not yet been reached, or has been exceeded. The acid used is 0.46 N HCl, which was selected because it titrates to an endpoint of 0.23 gram/100 cc. in apparatus of the capacity to be described. The indicator used is methyl orange which turns orange when the operator should stop the liquor recovery and divert the washings to the drain, but shows yellow when the washings still contain more than the specified concentration of ammonia.

Titration is accomplished in the actual sample bottle as follows: We use a 4-oz. wide-mouth bottle in which a No. 8 stopper with a ⅛-in. hole bored through it fits so its top is flush with the mouth of the bottle. To remove the stopper we have attached a wire hook. The bottle is filled with washings and the stopper is pushed in to remove the excess liquor through the hole and around the sides. When the stopper is removed (with our particular bottle and stopper) the bottle contains 96 cc. of washings. Then, filling it to overflowing with the standard acid adds just 28 cc. of acid.

Using such a bottle it is easy to calculate what normality of acid will titrate to the desired content of valuable material when the respective volumes of test material and standard solution are known. Once this has been done, a nontechnical operator can make the test in seconds with only a minute or two of instruction.



Manometer Cuts Meter Repair

Tseng-yung Yang

Maintenance Engineer, Chinese Petroleum Corp., Koahsiung, Formosa.

Our company has developed a method for protecting the positive-displacement meters widely used in the petroleum industry, which reduces maintenance and aids in trouble-shooting. This method consists in installing a strainer of proper mesh ahead of the meter and then hooking up a manometer across the strainer so that its condition can be seen at all times by the amount of pressure drop indicated.

Positive-displacement meters depend for their precision on close fits and the maintenance of minimum leakage between the rotating parts and the stationary body. It is important to exclude grit and abrasive material carried in the liquid by the use of a strainer.

In checking our maintenance records we were able to confirm a direct relation between abrasiveness of the material in the liquid and the amount of maintenance. We found that suitable minimum mesh sizes were as follows: 80 mesh for gasoline and similar liquids; 40 mesh for kerosene and diesel oils; and 20 mesh for heating oil.

In addition to having a suitable mesh size, it is important for the strainer basket to be kept clean. Sediment build-up will increase pressure drop and de-

---

Coming November 30: Controlling Flow of Filter Cake

By D. J. Hicks, Winner of the September Contest

★ How Readers Can Win

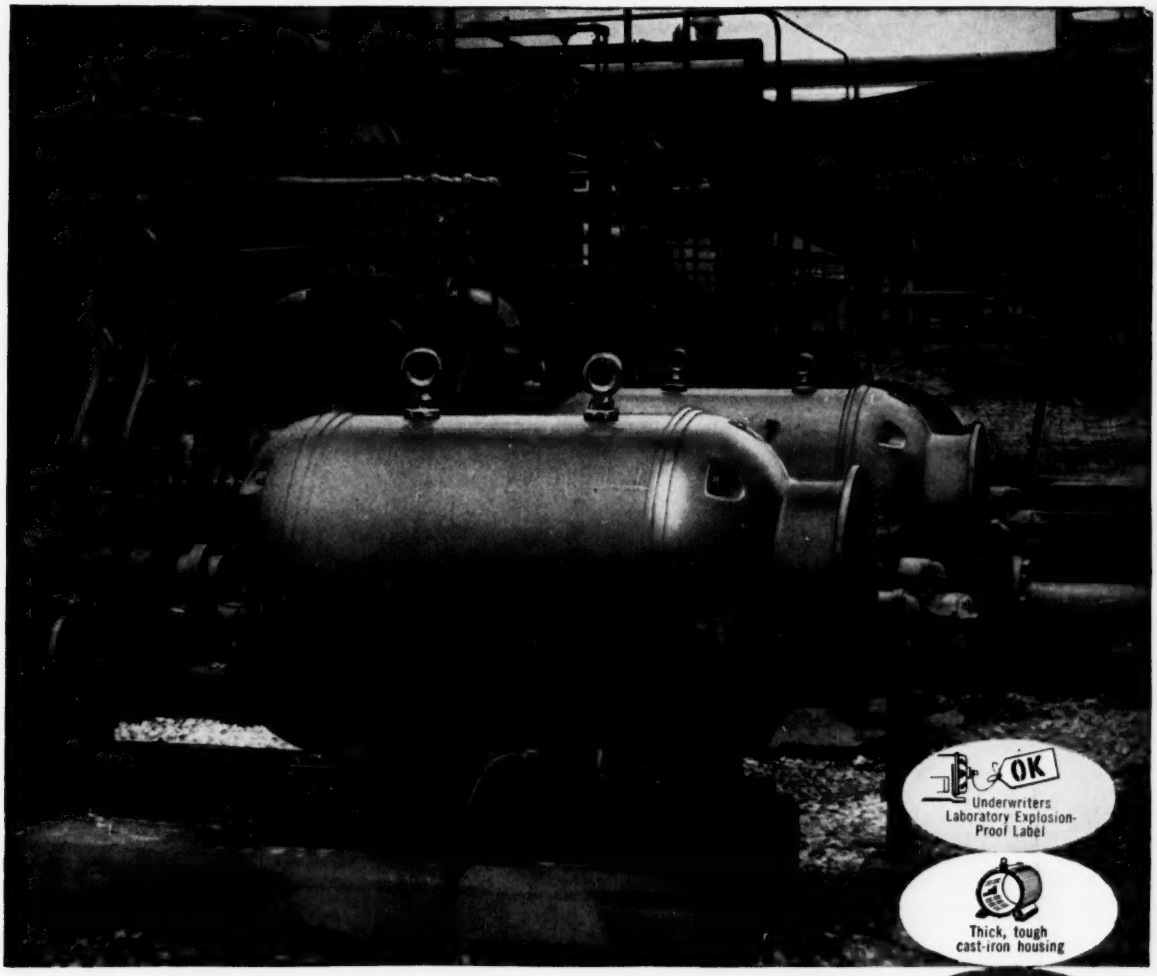
$50 Prize for Good Idea—Until further notice the Editors of *Chemical Engineering* will award $50 each four weeks to the author of the best short article received during that period and accepted for Plant or Process Design Notebooks.

Each period's winner will be announced in the second following issue and published in the third or fourth following issue.

$100 Annual Prize—At the end of each year the period winners will be rejudged and the year's best awarded an additional $100 prize.

How to Enter Contest—Any reader (except a McGraw-Hill employee) may submit as many contest entries as he wishes. Acceptable material must be previously unpublished and should be short, preferably not over 500 words, but illustrated if possible. Acceptable nonwinning articles will be published at space rates ($10 minimum).

Articles should interest chemical engineers in development, design or production. They may deal with useful methods, data, calculations. Address Plant & Process Design Notebooks, *Chemical Engineering*, 330 W. 42 St., New York 36, N. Y.



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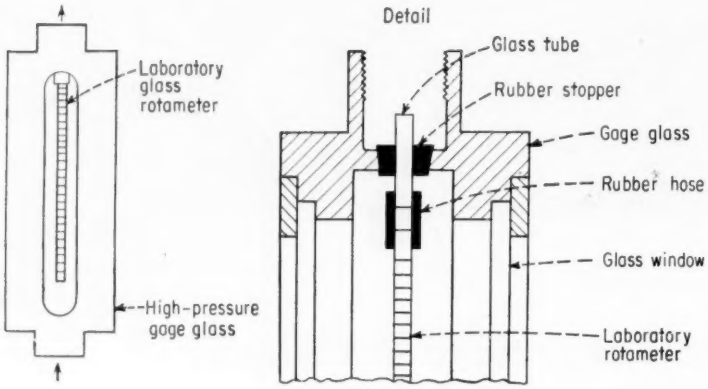
crease the flow. Complete clogging will probably lead to damage.

Initially, we set up a cleaning schedule which would insure frequent enough cleaning, but material accumulates at varying rates so that safety rather than the optimum interval became the rule.

After some years of experience in operating such meters we concluded that a varying cleaning schedule depending on pressure drop across the strainer would be preferable. Consequently, we connected a U-tube manometer across the inlet and outlet of each meter strainer. We used 10-in. mercury-filled manometers designed to handle the static pressure of the meter line. These are best provided with external micrometer adjustment for zero checking.

Most screen baskets for meter protection have a nominal open area ratio (screen to pipe) of about 5:1 to 8:1. With meters operated at about 75% of capacity this will produce an initial differential across the strainer of 1 to 3 psi. Any increase above about 3 psi. indicates the need for cleaning. Any decrease in differential below the normal for an average flow rate indicates a broken or leaking screen basket.

To aid the maintenance personnel in interpreting the manometer readings the meter scale can be painted with a warning color above and below the differential range for normal operation.



Minimeter for High Pressure

W. J. Burkett

Project Engineer, Monsanto Chemical Co., Plastics Div., Texas City, Tex.

Quite often, in bench-scale pilot plants, it's necessary to measure very small flows (cc.'s/min.) at high pressures. Commercial equipment isn't readily available but a simple solution is to use a laboratory glass rotameter inserted inside a high-pressure gage glass as shown.

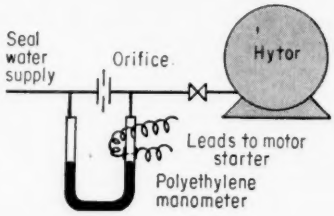
This arrangement has several advantages:

• *Economy*—The rotameter costs about $35 and the gage glass about $75. Since the pressure rating of the gage glass sets the operating pressure, the same rotameter can be used for any pressure.

• *Range*—Full-range flow rates (water) of 0-10 cc./min. can be obtained by just changing the float. Flow rates up to about 1,000 cc./min. can be had by changing rotameters.

• *Simplicity* — Both gage glass and laboratory rotameters can usually be obtained from suppliers as stock items.

One word of caution: Install a bypass and block valve with the meter to allow the system to be brought up to operating pressure without blowing the rotameter out of place.



Make Sure Your Seal Liquid Flows

M. Fridman

Project Engineer
Monsanto Chemicals (Aust.) Ltd.
Victoria, Australia.

In operating a Nash Hytor it is important to have the seal liquid running before starting the pump. Otherwise, the pump may be damaged.

There are several ways of interlocking the valve on the seal liquid line with the motor-starter switch. However, this is not enough; all these methods have the same fault in that the line valve may be open but there may still be no liquid flowing in the main.

The method sketched above enables the motor to be started only when liquid actually flows through the pipe. An orifice in the liquid line is provided with a manometer made of polyethylene tubing. The liquid in the manometer is mercury. Two metal wires are embedded in the low-pressure arm of the manometer about 1 in. above the mercury level in the no-flow position.

When the seal liquid is flowing, pressure drop across the orifice causes the mercury to rise in the low-pressure side and complete the circuit through the two metal contacts. These are wired into the pump motor-starter circuit so that only now is it possible to start the pump.

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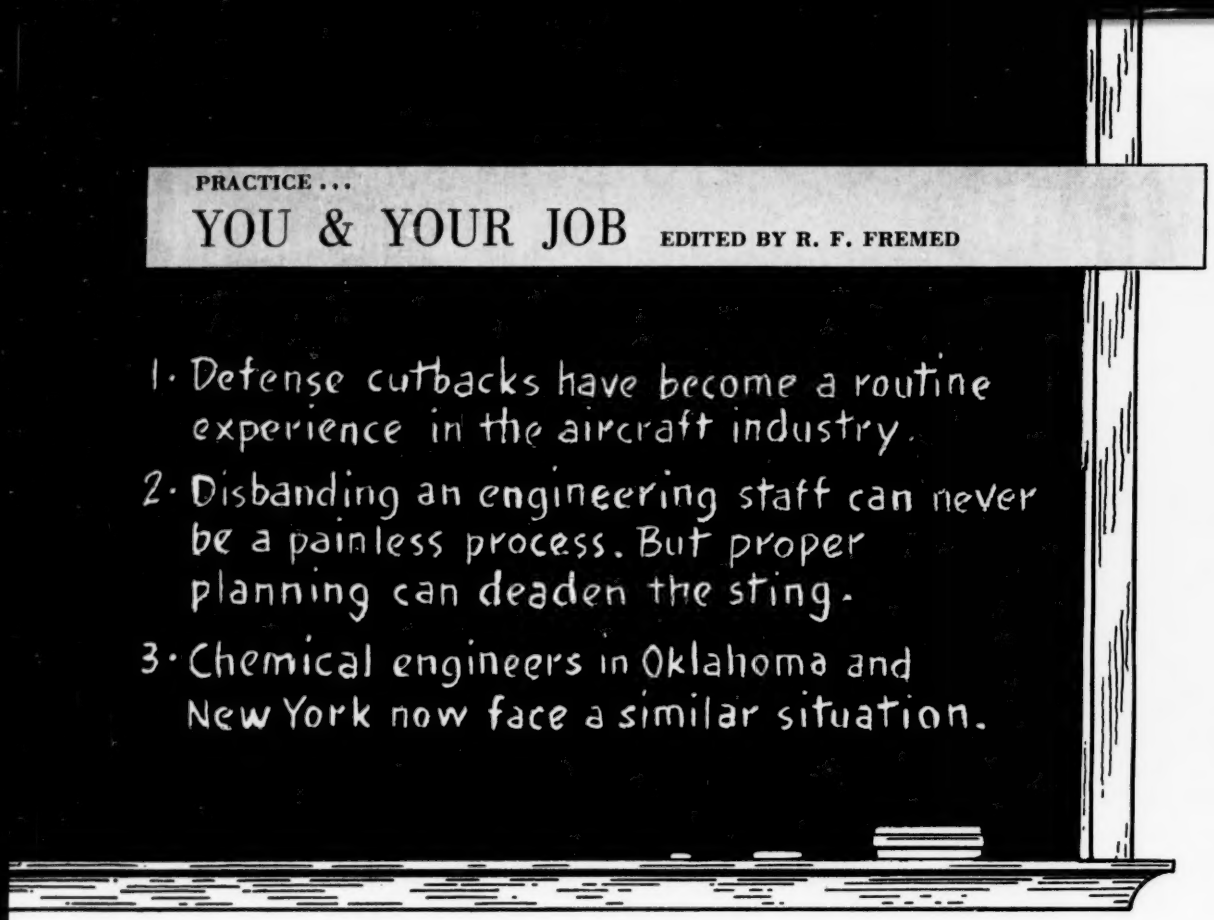

1. Defense cutbacks have become a routine experience in the aircraft industry.
2. Disbanding an engineering staff can never be a painless process. But proper planning can deaden the sting.
3. Chemical engineers in Oklahoma and New York now face a similar situation.

Lessons of a Technical Layoff

Late last year the Fairchild Engine & Airplane Corp. found itself in the unhappy position of having to disband its entire Engine Division.

Changing defense requirements had caused the cancellation of the Air Force's "Goose" missile program.

The contract for the design and development of the J83 jet engine for the "Goose" had been granted to Fairchild in 1956. To fulfill it, the company had been required to increase its engineering staff from about 300 to more than 850.

Now, at one fell swoop, this laboriously assembled technical team had to be let go.

Though most employers of engineers today may well be in precisely the reverse situation, the fact remains that any company working on a defense contract runs the risk of suddenly finding itself in the same boat as Fairchild. For this reason we feel that this account of how the company handled the layoff—and what it learned from it—is a matter of more than mere historic interest.

Actually, before the contract was canceled outright, Fairchild management received word that at least a partial cancellation was in the offing. Since it was clear that this would itself entail a sizable cutback in the Engine Div., a "disaster plan" to cover the orderly exodus of large numbers of engineers was immediately drawn up.

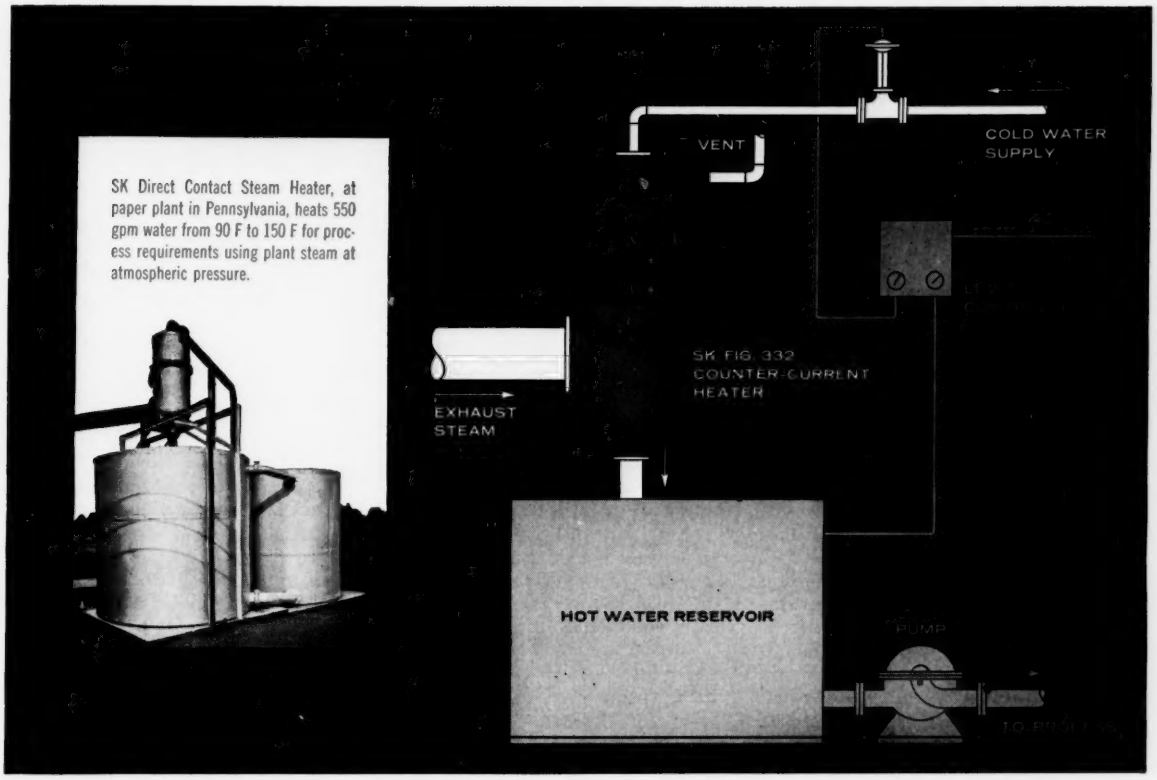
This plan was based on two fundamental concepts which were stated as follows:

1. Everything possible was to be done to help those engineers who were laid off to obtain other jobs.

2. The public relations, as well as the employee relations, aspects of the layoff were to be kept well in mind.

In brief the plan called for setting up a "job center" in the Fairchild plant. A list of all professional personnel scheduled to be laid off was to be compiled and distributed to other interested employers, coupled with an invitation to visit the plant and in-

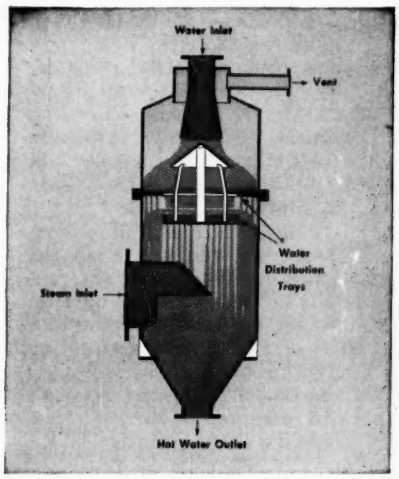
American Management Assn. has granted special permission to reprint this article from the Sept./Oct. 1959 issue of "Personnel." Authors: J. R. Harmon, Jr. & Felix Gardner.


SK Direct Contact Steam Heater, at paper plant in Pennsylvania, heats 550 gpm water from 90 F to 150 F for process requirements using plant steam at atmospheric pressure.
VENT
COLD WATER SUPPLY
SK FIG. 332 COUNTER-CURRENT HEATER
EXHAUST STEAM
HOT WATER RESERVOIR
PUMP

FOR HOT WATER IN LARGE QUANTITIES

use SK Direct Contact Steam Heaters

Sectional drawing of SK Fig. 332
Direct Contact, High Capacity, Steam Heater



SK Direct Contact Steam Heaters are designed to provide large quantities of hot water, or other liquid, for plant or process use. They do this by using plant exhaust steam (at low pressure or at vacuum to 15 in. Hg) to heat the water which is then delivered to a tank or reservoir.

To users, these high capacity heaters offer specific, worthwhile advantages. They are simple in design, have no moving parts. Heating, by condensation of steam in the liquid, is very efficient, continuous, and fast. A temperature rise of 130 F is possible with most of these units. Semi-solids in the liquid are handled without difficulty. Costs are reasonable and the heaters require little maintenance. Capacity can be just about any reasonable amount desired, since capacity is determined by heater size and SK has not established any maximum. Although cast iron and fabricated steel are standard materials of construction, other special materials can be used when required.

The counter-current unit pictured above and at left is one of four types made by SK. This particular heater and all of the other types are described in detail in Bulletin 3A-HC which includes application information and data on sizes, dimensions, and capacities. Copies of Bulletin 3A-HC are available immediately on request. Send for a copy.

JET APPARATUS: Ask for Condensed Bulletin J-1.
ROTAMETERS & FLOW INDICATORS: Ask for Condensed Bulletin M-1.
VALVES: Ask for Condensed Bulletin V-1.
HEAT TRANSFER APPARATUS: Ask for Condensed Bulletin HT-1.
GEAR PUMPS: Ask for Bulletin G-1.

Schutte and Koerting
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MANUFACTURING ENGINEERS SINCE 1876
2217 State Road, Cornwells Heights, Bucks County, Pa.

terview candidates on a specified date.

At the same time, lists of potential employers and employment agencies specializing in engineering placement were to be compiled for distribution to the employees affected by the cutback. It was also planned to provide a resume service, give personnel counseling wherever needed, and in general endeavor to make the layoff as painless as possible.

The Plan in Action

As things turned out, the orderly progression of steps envisaged in the original plan had to be telescoped somewhat.

With the outright cancellation of the contract, the entire Engine Div. had to be terminated forthwith. Nevertheless, though this meant that some refinements such as the resume service had to be dispensed with, in general the main features of the plan were faithfully carried out.

Thus, as soon as the news of the cancellation came through, potential employers on Long Island and in the metropolitan New York area, as well as some other companies doing similar work, were notified and invited to come to the Fairchild plant to interview the engineers who were being laid off.

Other companies, hearing of the situation, got in touch with us and were also given permission to join the interviewing group.

We set up our "job center" in the company cafeteria. Each visiting company was assigned interviewing space and given the opportunity to advertise its openings to Fairchild employees. These openings were also listed with a central exchange which we called "job control."

All job openings were cross-referenced by company and by type. Besides affording a ready reference to the openings available in the interviewing companies, job control also listed other job openings of which we were notified by telephone, or as the result of personal visits from company representatives.

Forty-four companies participated in the interviews which lasted three days. While some companies merely took applications, or extended invitations to selected employees to visit their plants, others made job offers on the spot.

Being curious to know the ultimate outcome of all this activity, we subsequently sent questionnaires to the 44 participating companies, as well as to 273 of the separated employees. Though the replies from the two groups could not be cross-validated, they yielded some interesting information.

Twenty-five companies replied to our questionnaire. With a little extrapolation, the returns showed:

- Of about 3,200 interviews, 2,200 were with engineering personnel.
- On the average, each company conducted 50 interviews.
- 300 job offers were made.
- One-third of the offers were for higher salaries; one-third for the same salary; and one-third for less.

Of the 273 employees queried, 103 replied. Their responses showed that:

- 25% had taken jobs in other geographical locations.
- 20% had had offers of the same salary.
- 80% had accepted higher salary offers.
- 10% had accepted the same salary.
- 10% were still unemployed after 30 days.

Further examination of the employees' returns showed that salary offers ranged from a 30% increase to a 16% decrease. Acceptances followed pretty much the same pattern—from a 30% increase to a 15% decrease.

The most frequently accepted increases were for either 20% or 10% of the engineer's previous salary.

Comparing the two sets of returns it will be noted that they are at variance in one significant respect. According to the participating companies, for each employee who was offered a higher salary, another was offered a lower one.

However, 80% of the employees themselves said that they had received higher salary offers.

If the information furnished by both groups is correct (and there is no reason to believe otherwise), it can only be supposed that, for the most part, the job-seekers did not report their actual salaries to the hiring companies.

This supposition is, in fact, borne out by personal inquiries in some cases. Such information as could be obtained from these sources indicates that salaries were inflated by about 10%.

Offers Must Be Higher

Two significant points would appear to be underscored by these findings:

1. To recruit professional personnel in a competitive situation, the employer must offer the engineer more than he is making—probably from 10 to 20% more.
2. On the whole, capable engineers can obtain positions at higher salaries elsewhere. This is clearly a challenge to companies to follow policies calculated to retain their engineering staffs.

Aside from this incidental intelligence, our appraisal of the results of our layoff operation gave us good reason for satisfaction. Many of the participating companies expressed their appreciation of the way in which the job center had been conducted. Needless to say, they were equally pleased with what they had gained from it.

Community relations were maintained at a high level; state employment officials were laudatory; and—perhaps most important of all—the employees who were laid off were universally agreed that the company had done everything possible to ease the situation.

In short, the Fairchild job center proved beneficial to all the parties concerned, and was generally hailed as a signal advance over the "dog eats dog" practices that disfigure most engineering recruitment programs.

NOTE—Mr. Harman is now with Grumman Aircraft Engineering Corp., Bethpage, N. Y.; and Mr. Gardner is associated with Servo Corp. of America, New Hyde Park, N. Y. At the time described in this article, they were employed by Fairchild as Asst. Manager and Manager, respectively, of manpower, recruitment and training for the Engine Division.

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Name			
Chemical Formula			
Bulk Density (lbs./cu. ft.)			
Moisture (% H_2O)			
Melting or Softening Point (°F.)			
Toxic (yes or no)			
Feed Temperature			
Particle Size (mesh distribution)			
Other			

THE PROBLEM: (Include capacity, distances, elbows in system, etc.)

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REQUESTED BY:

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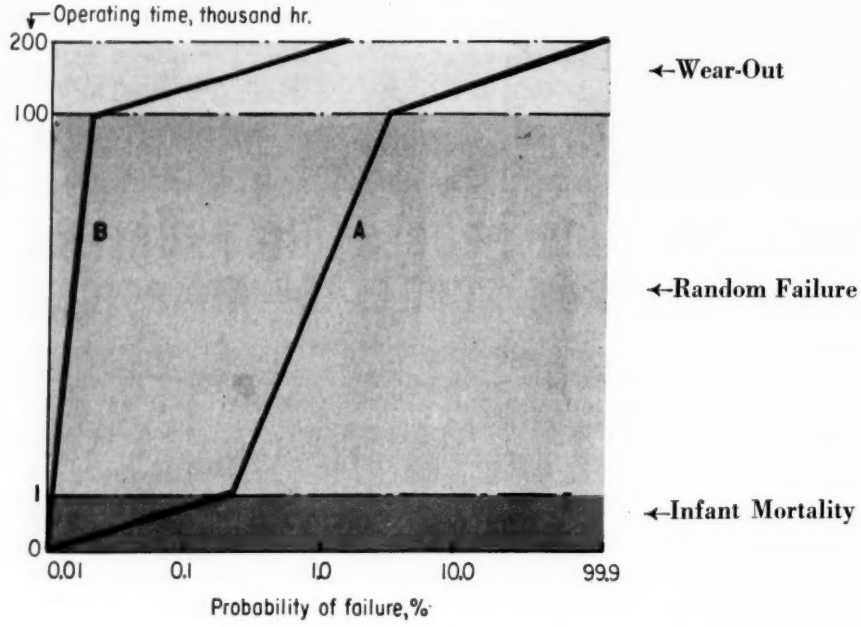
Reliability Curve Shows Failure Falls Into Three Categories



Increase Equipment Reliability

By Studying Cause of Failure

I. J. KARASSIK, Consulting Engineer and Manager of Planning, Worthington Corp., Harrison, N. J.

By studying the cause of failure you can develop a frequency or reliability curve and get a good indication of areas ripe for improvement.

It is characteristic of the components of modern processes that they must operate under more severe and exacting conditions than ever before. It's just as characteristic that these components must perform with a greater degree of reliability, because unscheduled interruptions —particularly those affecting production—have become more important.

In other words, just when equipment failures are becoming more costly and less welcome, they have also become much more likely to occur as a result of the increasing complexity of the processes and all their component parts.

We are faced with a conflict between the need for greater reliability and the impact of problems that threaten reliability.

My studies* of the reliability of the centrifugal pump leads me to say that the concept of "reliability" requires clarification.

Reliability is a concept, an idea, but it's also a real thing even though you can't always express it numerically. Once you understand this, it's possible to apply logical steps in evaluating

* "A New Search for Criteria of Equipment Reliability Evaluation," presented to the Maintenance and Plant Engineering Div., ASME, St. Louis, June 14-18, 1959.

Lubrication News

PROFITABLE IDEAS ON THE LUBRICATION OF CHEMICAL PROCESS EQUIPMENT

Deposit analysis can uncover surprising reasons for failure

When equipment fails, industry's natural tendency is to blame the lubricant. For this reason, samples of oils and greases — often no more than mere specks—sections of failed gears, ruined bearings and other pieces of equipment are analyzed at the Texaco Research Center, Beacon, N. Y. Here they are subjected to a searching analysis by technical service experts using a tremendous catalog of apparatus and procedures.

Lubricant is seldom guilty

Of the numerous samples submitted every year, the lubricant is guilty in less than 1% of the cases. Take a typical example:

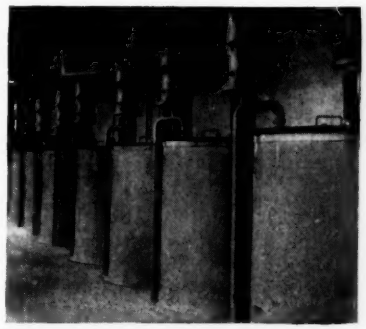
A customer submitted a severely corroded roller bearing. The bearing and its lubricant were liberally contaminated with both red and black material. X-ray diffraction analysis disclosed that the contaminant was an alpha ferric oxide which is characteristic of fretting corrosion—usually correctable only by a design change. Had ordinary rusting occurred the contaminant would have been hydrated ferric oxide —and a finger could have been pointed at the lubricant for allowing water to come in contact with the bearing.

The March 1958 issue of *Lubrication Magazine* contains a fascinating series of these "detective stories." Write for your copy—the supply is limited.

NEW GREASE WITH EP PROPERTIES TAKES 400-700° F. TEMPERATURES

In three years of field testing, a new grease called Thermatex EP 1 has:
— lubricated equipment in which temperatures reached 700° F.
—effectively lubricated equipment handling corrosive chemicals.
— resisted coking and solidifying in steam joints, where temperatures reach 400°. In this application, steam is present, and the grease is pumped through 35 feet of ⅜" tubing.

In these steam joint tests, previous failures of the automatic pumping unit and of the steam joint had resulted when grease solidified and coked in the last foot of the line. These failures occurred as often as every two weeks. During a two-year test with Thermatex EP 1, no failures whatsoever occurred due to lubrication, and no evidence of coking or plugging was recorded. Several joints were operated for more than 9 months with no need for maintenance.



Thermatex has been tested successfully as seal and lubricant for packing-type bearings in mixing machines, similar to these, which handle corrosive alkalis and acids at temperatures to 275° F.

Characteristics and properties

Thermatex EP 1 is a high temperature grease of No. 1 NLGI consistency containing EP additives. It has good heat stability (dropping point: over 500° F.), good shear stability, excellent water resistance, and good wear characteristics. It provides excellent lubrication, and will not separate or harden excessively under pressure.

Information now available shows that Thermatex EP 1 will lubricate satisfactorily at 450-500° F., when relubrication occurs every 3 or 4 days. It will provide adequate lubrication at 550° F., with more frequent lubrication periods. While useful lubricant life at temperatures above 550° F. is measured in hours, use of centralized pressure systems should insure completely adequate lubrication.

For complete information and additional test results, check the coupon.

Guide to Organized Lubrication

Organized lubrication, as a means of controlling costs, is discussed from management's point of view in this important booklet. It describes methods that help raise production, extend parts life, cut downtime.
For free copy, use coupon below.

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New York 17, N. Y.

I am attaching my company letterhead to this coupon.

- ☐ Send a copy of "Management Practices that Control Costs via Organized Lubrication."
- ☐ Send information on Thermatex.
- ☐ Send copy of March, 1958 Lubrication Magazine.
- ☐ Send information on Air Tool Lubricants.
- ☐ Ask a Texaco Lubrication Engineer to call at my plant.

Name _____

Title _____

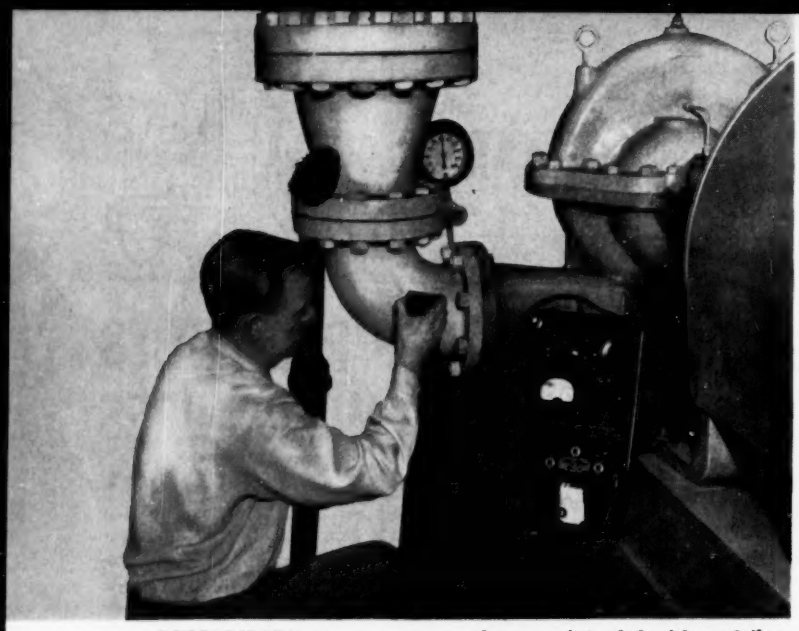
Attachments lengthen life of air-powered equipment

Moisture and insufficient lubrication are major causes of parts wear in air-powered tools and mechanisms. Yet, two simple attachments for the air line, plus one precaution, can eliminate these causes of wear completely.

1) Insufficient lubrication can be overcome with an air line lubricator, which sprays lubricant into the line. The air carries this atomized oil to the tool or mechanism, where it lubricates internal parts thoroughly.

2) Moisture in the air line can be arrested by a water trap, filter or drain, usually attached just before the oil injector. This prevents the moisture from mixing with the lubricant. Otherwise, a thick, emulsified liquid will form that lubricates poorly and may cause rusting.

Water traps should be emptied regularly. If the lubricant in its glass bowl on the injector is white and foamy, immediately drain the trap and replace the lubricant in the bowl with a new supply.



RELIABILITY means a pump performs as intended without failure.

I have chosen to use this par- different designs, techniques, applications and operating practices.

Because of my long term association with centrifugal pumps, ticular piece of equipment to illustrate this search for new criteria of reliability evaluation. I fully realize that I risk finding myself between two camps.

On one hand, there are the reliability experts to whom the tremendous impetus of aircraft and missile construction have given great insight into this problem. To them this paper may appear as merely an elementary introduction to the subject.

And on the other hand, there are engineers to whom a search for a new approach into equipment evaluation appears as an entirely unnecessary academic exercise.

What Is Reliability?

This word, "reliability," is possessed of very intangible characteristics. I have frequently tried to define it, but never succeeded in improving a definition I once read in the advertisement of a firm manufacturing components for electronic computers:

"The reliability of a particular component or system of components is the probability that it will do what it is supposed to do under operating conditions for a specified operating time."

This definition illustrates how difficult it is to assign a significant number to the reliability of a pump. To calculate or predict a probability, it's necessary to carry out statistical research with a number of units much higher than is available for such research.

To define operating conditions, it is not sufficient to list required capacities and pressures, prevailing temperatures and expected variations of these three items. It is also necessary to predict any and all possible other factors and events that may interfere with the ability of the pump to "do what it is supposed to do."

What Is Probability?

We said reliability is the probability that a certain component or system of components will do what it is intended to do. But what is probability?

If we consult a dictionary, we find that of the precise meaning of "probability," there are conflicting views among philosophers, mathematicians and statisticians. But for our particular purpose we can do with a reasonably simple definition, equating the term "probability" to that of "chance."

In other words, if chances are 1 out of 100 that a certain event will occur, the probability is 1 out of 100, or 0.01. Total probability of all alternate events is 1.00, that is 100%. Reliability of a component is the probility of that it will not fail, or 1.00 less the probability of failure; if 10 components out of 1,000 similar components fail, the probability of failure is 0.01 and the probability of successful operation or reliability is 1.00 less 0.01, or 0.99.

We know something more about probabilities. We know that the probability of a series of events is the product of their individual probabilities.

Let's look at a system of 100 components which, when operated together, make up a chemical plant. If successful operation of the plant requires successful operation of each component, then reliability of the plant is the product of the reliabilities of the components.

Assume individual reliabilities of the components are 0.99; reliability of the plant is 0.99 multiplied by itself 100 times, or 0.3665.

In simple terms, we could expect a plant to be out of service about two-thirds of the time and only one out of each three chemical plants to operate satisfactorily. Two plants would be in unscheduled outage.

This is certainly a cheerless conclusion to reach and one that we know to be contrary to experience.

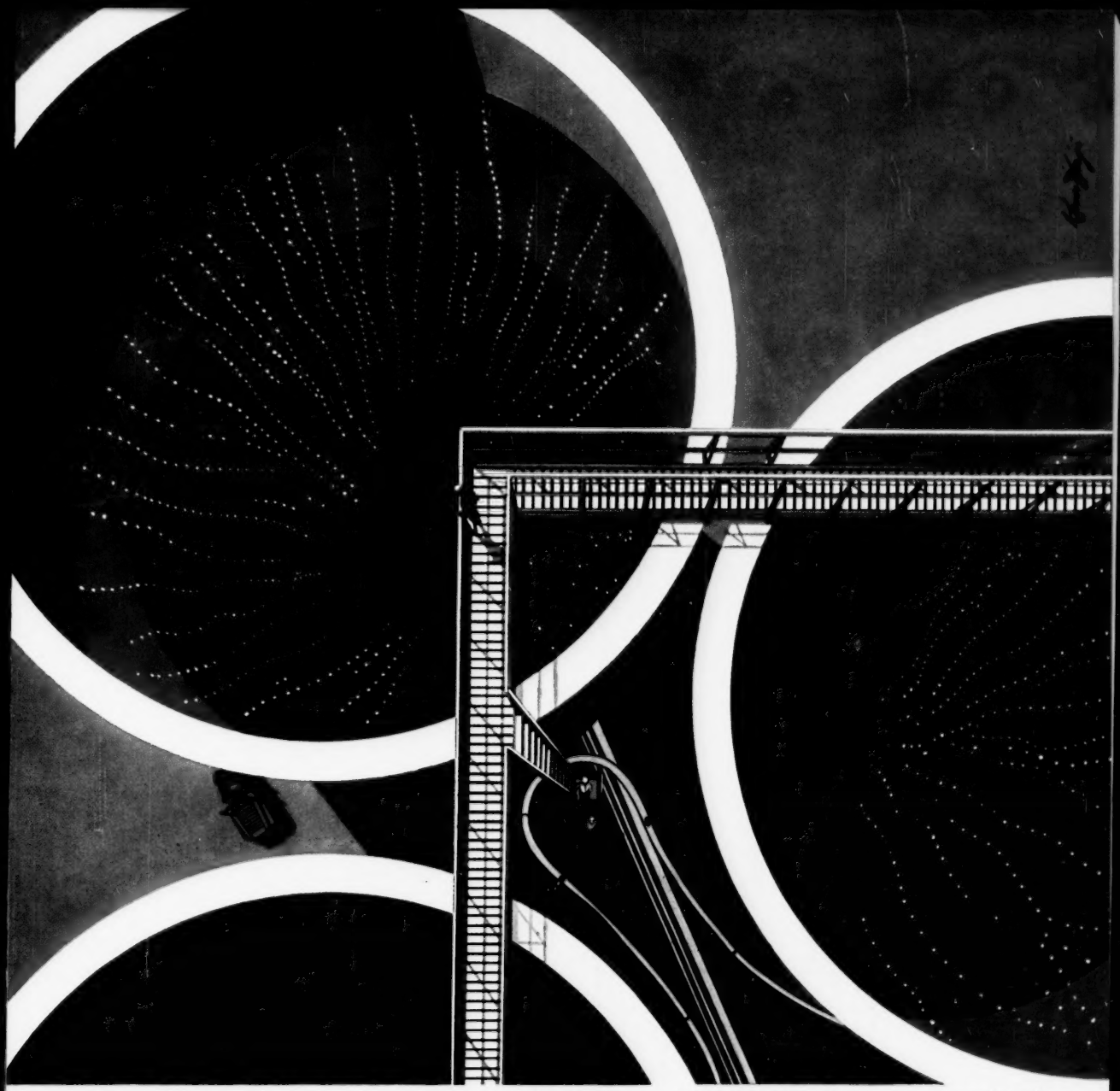
Then, what is wrong with the assumption we made?

There are certainly at least 100 critical components in a typical chemical plant, the successful operation of each one of which is essential to operating the plant. Our error, more than likely, is assuming the reliability of each component is only 0.99. If we assume an individual reliability of 0.999, the overall reliability quickly climbs from 0.3665 to 0.906.

Let's try again. If individual reliability is raised to 0.9999 (1 failure out of 10,000 units), overall reliability is 0.991.

Reliability factors for a group of dissimilar components don't fall neatly into line as 0.99 or 0.9999 but are probably a family of factors ranging between 0.99 and 0.9999. Still this example is useful to illustrate the cumulative effect of the reliability of a large number of individual components.

Of course, some distinction can be made as to the extent of equipment failure. There's a



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marked difference between a complete pump failure in a plant with no standby pump and a leak in a heat exchanger tube where the exchanger can be temporarily bypassed for repairs without shutting down the entire plant.

Likewise, there may be some argument as to the number of items comprising the whole. Is each heat exchanger considered a component or each tube in the heat exchanger? Is the pump with its drive and controls one unit, or three? Or is each pump made up of hundreds of individual components, each with its own reliability factor, each factor of equal weight in evaluating over-all pump reliability?

Admittedly, this choice of numbers influences the meaning of the reliability factor. But in our particular case, the question is strictly academic: we are not aiming at establishing a valid, quantitative value for the probability of failure of a chemical plant, but rather at developing a climate—a mode of thinking of reliability and of all the factors that may affect it.

Regardless of how much we learn about precise numbers, the consideration of conditions that could affect reliability could in itself be our most important achievement.

When we try to improve the reliability of a given piece of equipment even the slightest bit, we aim to achieve very important improvements in the sustained operation of the process or of the plant that's served by this equipment. This remains true whether we can measure reliability or not.

IGOR J. KARASSIK, a name well known to CE readers, is Consulting Engineer and Manager of Planning, Harrison Div., Worthington Corp. He holds both BS and MS degrees from Carnegie Tech. Karassik joined Worthington in 1934 and since 1936 has specialized in the application of multistage high-pressure pumps.

Can We Classify Failures?

Even if we can't assign a significant number to the reliability of a component such as the centrifugal pump, we can attempt to classify the failures of which this equipment can be a victim.

A recent article on maintenance problems ("Developments in the Analysis of Maintenance Problems" by J. D. Quinn of the Dupont Co., *Mech. Eng.*, Oct. 1957, p. 931), gives an entirely new point of view on the subject of reliability. It proposed a classification of service interruptions from component part failures into three groups:

- Infant mortality
- Random failures
- Wear-out

Infant mortality is defined as that group of failures that occur in the early stages of operation and which can be ascribed to faulty components, faulty installation or initial operating procedures.

Random failures indicate a situation that could be classified as "out-of-control."

Wear-out classification can be a "normal" situation if the operating hours approach the expected or designed life of the components.

Number of operating hours for a large group of machines or components can be plotted against the probability of failures. Such a typical curve is shown on p. 126.

Shape of this curve discloses a very definite subdivision of all failures plotted into these three categories. What is more important, it gives an immediate indication of the areas where improvements can be made by careful analysis and changes in design, operating procedures, etc.

For instance, if faulty installation is causing excessive infant mortality, proper training of the mechanics remedies this problem.

Excessive random failures may indicate the inadequacy of the components to withstand certain unanticipated overloads.

Wear-out which occurs considerably below the expected life of the equipment may require material changes or product redesign to meet prevailing operating conditions, apparently too severe for existing design parameters.

Such a curve is readily constructed if we are dealing with a mass-produced and mass-applied item on which reasonably accurate records are available. Thus, a situation initially described by Curve *A* can be improved to yield Curve *B* by reducing infant mortality and random failures.

When it comes to process pumps, there's an immediate obstacle: the number of pump installations is not high enough and operating conditions vary too much from plant to plant for such statistical studies to be valid. Also, accurate records of failures in the field—of either minor or major nature—are not readily available.

One may say, then, why introduce this concept of failure classification when we cannot prepare a quantitative curve that gives us any clue to the wisest course to follow in our choice between different designs or arrangements? I feel the concept is useful for focusing our attention on the differences existing between various types of pump failures.

We can begin by dispensing entirely with the wear-out problem by assuming that if you choose the proper material initially, the life of the modern process pump is generally quite satisfactory if no other causes of failure interfere with the gradual process of wear in the internal clearances.

We can likewise pay just nominal attention to the random failure portion of the curve on the assumption that the user selects his equipment with the thorough understanding that some designs withstand certain transient operating conditions better than others.

We are left to deal with infant mortality. What are the factors, then, that can contribute to infant mortality of process pumps? We will get into this and the related problems of economy and first cost in the second part of this series.

Photo Courtesy E. I. DuPont de Nemours & Co., Inc.

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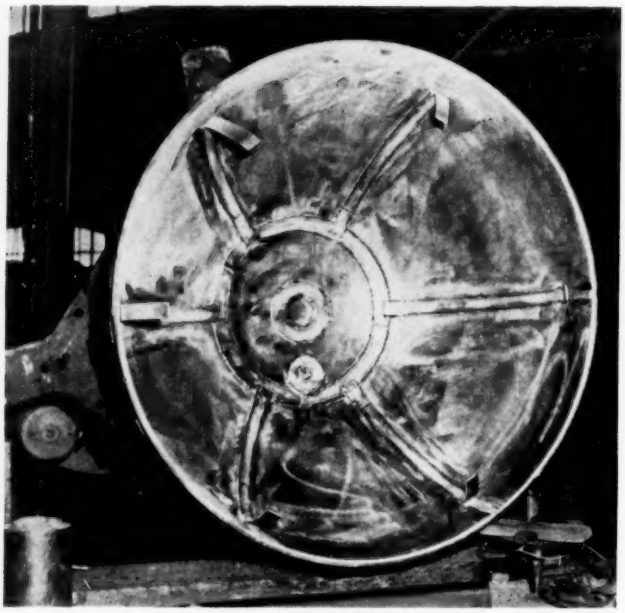
PRACTICE ...

CORROSION FORUM

EDITED BY R. B. NORDEN



TITANIUM STRAP over silver inlay—key fabrication step.

Inlay Makes Ti-Clad Vessels Possible

New joining technique avoids brittle titanium-to-steel welds during construction. Commercially available clad equipment now offers one way to cut down on titanium's cost disadvantages.

One long-standing obstacle to construction of titanium-clad steel equipment—welding—has been overcome.

At least one manufacturer now says "feasibility of fabricating large titanium-clad vessels from integrally bonded sheets has been proved."

Backing up this claim with more than mere words, Chicago Bridge & Iron, Chicago, Ill., offers to build Ti-lined equipment.

▶**Proof Positive** — This announcement follows successful tests on a Ti-clad vessel at a "California petrochemical firm." Measuring 4-ft. in dia., 12-ft. in height, the reactor handles a working pressure of 150 psi. at 500 F.; has been in service since early this year, processing extremely corrosive materials.

A reactive metal when molten, titanium presents a real problem when it has to be joined to other metals. For instance, a titanium-to-steel weld is possible, but the weld is extremely brittle and useless. So it's not practical to weld titanium-clad sheets directly.

▶**Silver Inlay**—CB&I sidesteps this situation by using a transition material between the car-

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for dependable performance and long service life with minimum maintenance costs, Series H Durcopumps are in a class by themselves. They are designed and built to give long, trouble-free life when handling *tough* corrosive solutions. A large, rugged shaft and heavy duty bearings insure minimum shaft deflection, and provide long seal or packing life. Integral suction and discharge with casing support makes for easy three-step, one-trade maintenance. DURCOPUMPS are available in twelve standard corrosion resisting alloys with capacities from ½ to 3500 gpm, and heads to 345 ft.

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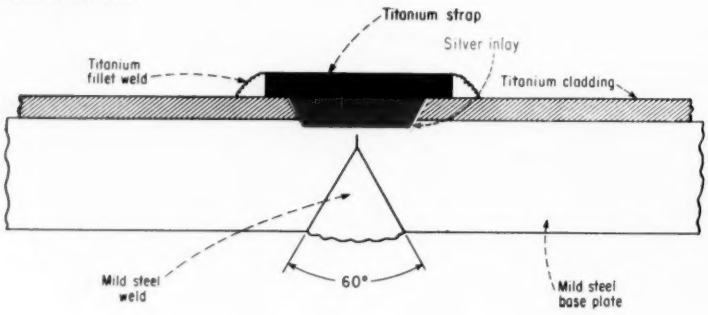
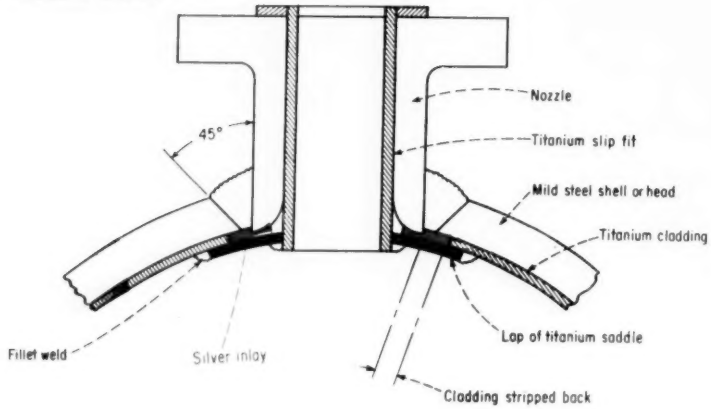
Strap-Over-Silver Joint Works for Shell and Nozzles

Shell Detail



Nozzle Detail



bon-steel backing plate and titanium. The technique somewhat resembles Lukens Steel's weld for joining stainless clad pipe (*Chem. Eng.* Aug. 24, 1959, p. 162). For titanium, CB&I closes the seams in vessel construction by putting down a silver inlay at the joint, on the titanium side, and capping this with a titanium cover strap (see photo and drawings). This step comes after the steel backing plate has been joined by a standard carbon-steel weld.

The strap method avoids any steel-to-titanium welds, and presents an all-titanium surface to a corrosive. For complicated shapes (heads and nozzles) the straps have to be overlapped.

On nozzles, the strap technique gets a little complicated, particularly where nozzles join head plates at sharp angles. Here oval straps do the trick. All nozzles and flanges in clad vessels will have titanium liners (not clad).

▶**Big Plates** — The vessel in California was fabricated of 0.078-in. thick, commercially pure, titanium sheets bonded to ½-in. mild steel (ASTM A285). Composite plates for the head-centers and manhole neck, shell, bottom head and top head were 2-ft. 1-in. by 4-ft. 7-in.; 5-ft. 6-in. by 6-ft. 8-in.; 5-ft. 2-in. by 6-ft. 1 in.; and 5-ft. 2-in. by 6-ft. 1-in. respectively. Fabrication complied with the ASME pressure vessel code.

Of course, CB&I uses its well-known patented flux-free vacuum bonding process.

But some special handling was called for. One striking characteristic of titanium is spring-back when cold formed. In fact, 50 or 60-degree spring-back is not uncommon. When forming is not severe, this property doesn't give much trouble. But on head pieces, for instance, the clad plates must be worked warm, at about 500 to 600 F.

While cost of a Ti-clad vessel is generally lower than solid Ti construction, there isn't much of an advantage for wall thicknesses below ⅛-in. While cladding reduces amount of titanium, it also calls for expensive silver and the breakeven point seems to be around ⅛-in., at least for the present.

▶**Part of Trend**—Just how far will this latest development boost titanium in the process industries? There is no easy answer to this question. Certainly new titanium improvements are coming thick and fast.

Recently Union Carbide Metals announced a more resistant Ti-alloy, which can handle both reducing and oxidizing corrosives. (*Chem. Eng.*, May 18, 1959, p.200). Since this alloy has most of the physical and mechanical properties of pure titanium, there's no reason why it couldn't be used as a cladding.

▶**Prices Down**—Also, price reductions, announced early in 1959, bring titanium down, somewhat, from astronomical figures.

Base prices for titanium metal now are: billet, $3.55/lb.; bar, $4.25/lb.; plate, $5.25/lb.; wire, $5.75/lb.; strip, $7.25/lb.; and sheet, $7.75/lb.

These prices are 50% below 1954 figures and approach the cost of some highly alloyed grades of steel and nickel-based materials.

Use of clad equipment is, of course, one way to reduce Ti's cost even more. And there may be other developments coming along in this area. It's known that Lukens Steel has been working for some time on development of Ti-clad equipment. They have announced availability of sheet clad with titanium; but no word, at this writing, on equipment. Some experts believe Lukens has another approach to the welding problem, which doesn't call for a silver inlay.

Corrosion Forum

(*Continued on p.* 122)

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COST-CUTTING techniques make 4,500-ft.-long, 8-in.-dia. aluminum pipeline at Point Comfort, Tex., competitive with wrapped and coated steel.

Al Pipeline Costs Near Steel

Cheaper pipe and new welding technique bring cost of buried aluminum pipelines to within 4% of less resistant coated-and-wrapped steel installations.

Some bad news for steel comes from Alcoa.

With a recently developed automatic pipe welding technique, Alcoa has installed 4,500 ft. of 8-in. aluminum pipe as part of a gas-gathering system at its Point Comfort, Tex., operations. Buried without protection in marshy, salt-water-containing soil, the line costs about 4% more than coated- and wrapped-steel pipe.

▶ **Closing Cost Gap** — Alcoa claims this initial cost difference will be quickly overcome mainly by aluminum's superior corrosion resistance.

Key to bringing the cost differential down to 4% is a new, portable automatic fusion welder capable of handling 4-in. to 11-in. dia. pipe. The machine uses a consumable electrode, with an argon blanket around the arc. Very fast, the welder, can complete a pass on 8-in. pipe in 17 sec.

Also, this welder is the first capable of producing good welds on aluminum, with full penetration, without use of back-up rings. This means rings don't have to be withdrawn through 40 or 80 ft. of pipe—a time-consuming operation.

▶ **Automatic Welding** — To use the welder, an operator first positions pipe, which then is gripped by mechanically operated clamps. Final positioning and aligning is done mechanically. Welding head rotates into position and the welding wire is lowered all automatically with the press of a button.

A finely regulated motor permits good speed control of wire feed and head rotation during the actual welding operations. And the torch can be tilted away from the welding position for servicing, without disturbing the pipe in the machine.

At Point Comfort, Alcoa used 8-in. Schedule 40 seamless, heavy-end pipe (Alloy 6063-T6). Nominal wall thickness at ends is 0.322 in.; while it's 0.204-in. along the pipe length. This pipe cost 20% less then usual aluminum pipe for the same pressure rating.

The line is made up of 40-ft. sections. It will carry dry gas at 500 psi., and conforms to ASA codes for pressure piping.

Alcoa first proved effectiveness of bare aluminum pipelines with installations made 11 yr. ago. Additional evidence was added 2½ yr. ago, by installation of an uncoated 8-in. line at Point Comfort. It extended 20,000-ft. through sand, gumbo and salt marsh. Experience since indicates that aluminum pipelines will give long, low-cost service.

The original elimination of coating and wrapping, normal procedure for steel pipe, was also a big factor in reducing aluminum pipeline costs.

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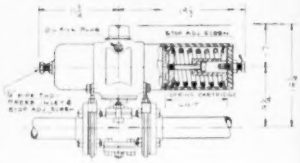

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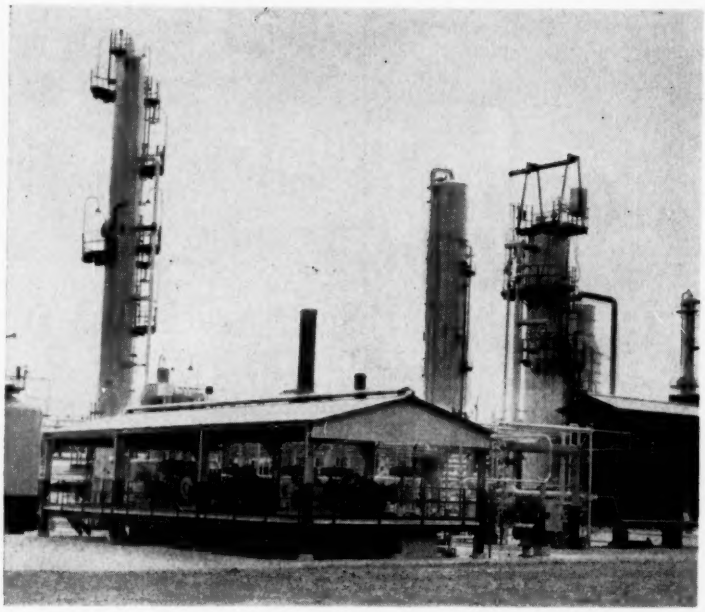


Distillate Desulfurizing Unit to Sweeten Feed Stocks

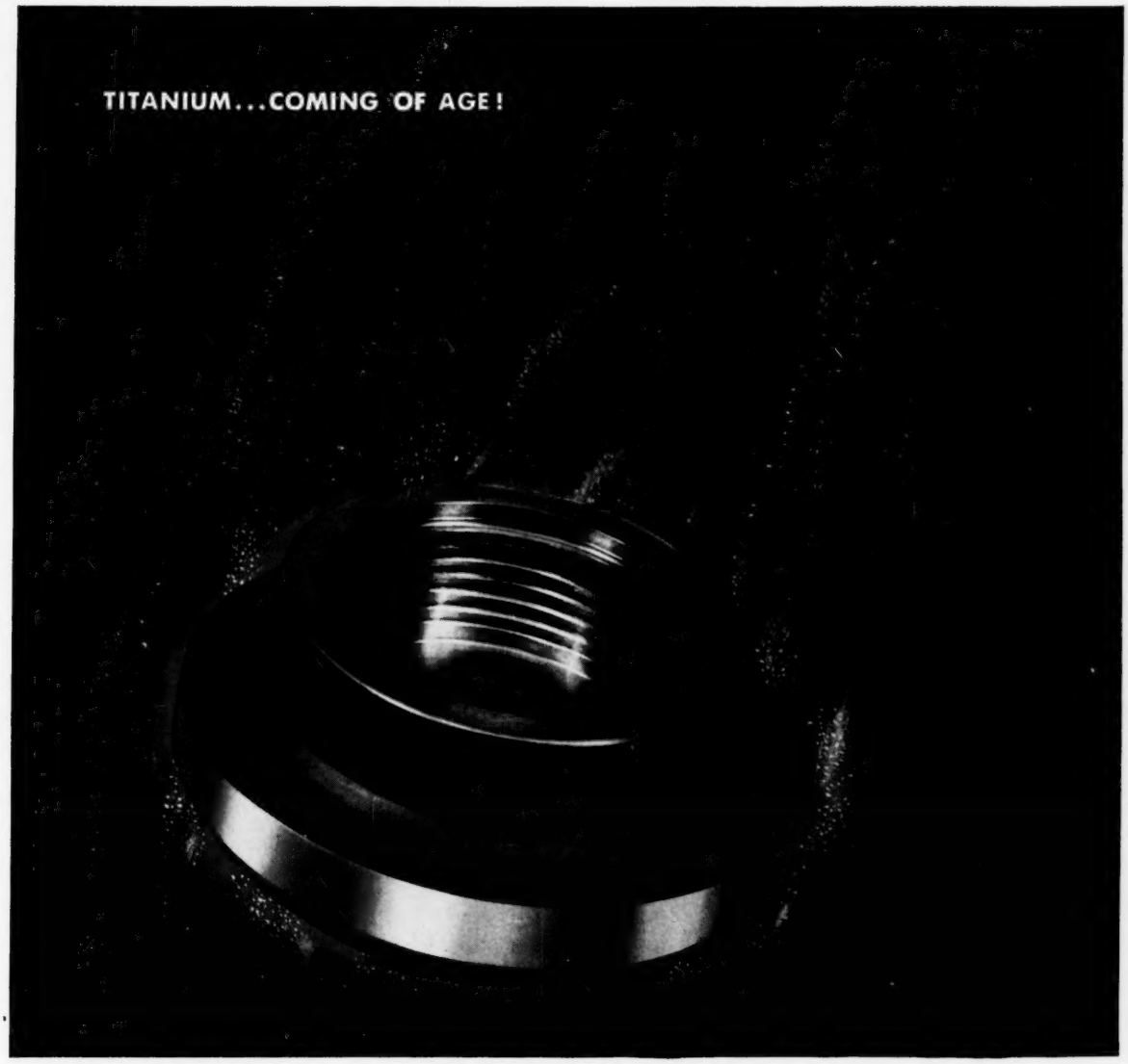
British American Oil Co. has just placed on stream this 8,000-bbl./day distillate desulfurization unit at its Clarkson, Canada, refinery. New unit will remove 90% of the sulfur content from three charge stocks: fluid-catlytic-cracking light-cycle oil, stove and diesel base. Canadian Kellogg Limited of Toronto, Ont., completed the design, engineering, construction and equipment procurement for the new facility.

Union Carbide Plastics Co. is planning two large polyethylene-plant expansions, to increase its high-pressure polyethylene capacity by 85,000 tons/yr. Construction of new capacity at Seadrift and Texas City plants is now under way, is scheduled for completion by 1961.

Phillips Chemical Co. is increasing its ethylene capacity at its Sweeny, Tex., plant. Just last month, a 37,500-ton/yr. expansion went on stream; another 17,500 tons/yr. is scheduled to go on stream by mid-1960. When capacity increases are completed, it will reach the 145,000-ton/yr. mark.

Dow Chemical Co. reveals plans for construction of a polypropylene plant at its Torrance, Calif., plastics-production facility. This will be the first polypropylene plant on the West Coast of the U. S.

Bunker Hill Co., San Francisco, Calif., reveals plans for construction of a fertilizer plant in Kellogg, Idaho, adjoining its mining operation. First step, now under way, is the construction of a $2-million phosphoric acid plant. Low-cost sulfuric acid, available



Titanium powder now economically formed into strong, lightweight, corrosion-resisting parts

Titanium has entered still another fabricating field . . . powder metallurgy... that adds to its growing usefulness in the chemical, processing, and other industries.

Today you can design titanium parts to be formed by powder metallurgy techniques that combine strength, purity and corrosion resistance equal to wrought titanium. Close tolerances permit a minimum of machining on contacting surfaces; none on non-contacting surfaces. An example is the chemical valve seat, above, made by Clevite Corporation of Cleveland, Ohio.

Finished parts weighing from less than an ounce up to many pounds are being produced. Shape can range from simple gear or cam blanks to complex pieces with wide variation in cross-section. Titanium powder metal parts compare favorably in cost with wrought and machined parts.

To learn more about the growing use of titanium powder metallurgy for corrosion-resisting, light, strong parts, write us. Union Carbide Metals Company, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. *In Canada:* Union Carbide Canada Limited, Toronto.

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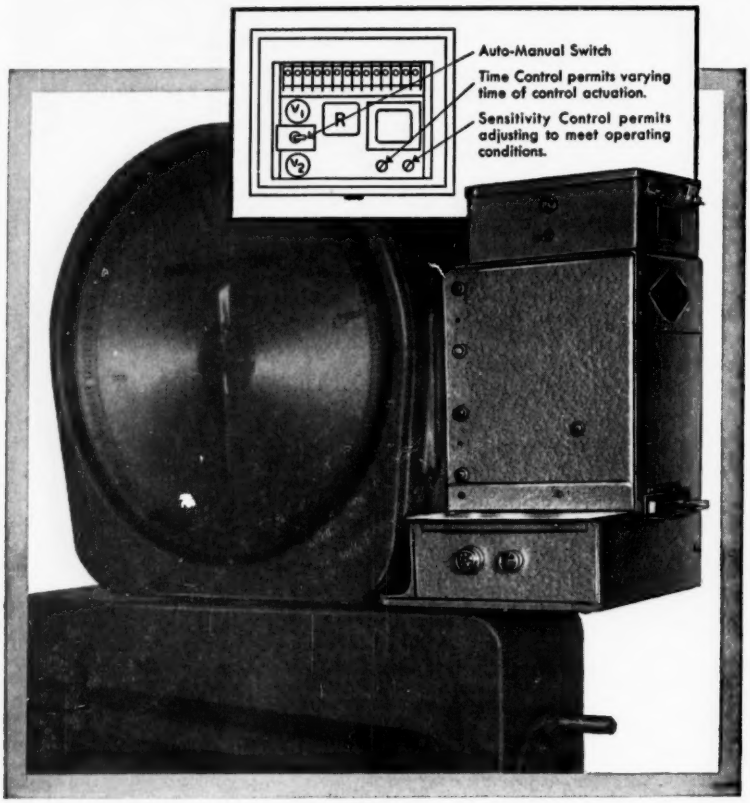
NEW Fairbanks-Morse Electronic Weight Detector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Time Control permits varying time of control actuation.
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Prevents incorrect weighing . . . stops costly errors!

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at this location, will be used to acidulate the phosphate rock.

Phillip Morris, Inc., has just dedicated its new multimillion-dollar research center at Richmond, Va. Shown above is its $65,000 mass spectrometer, now used to detect and measure the constituents of tobacco smoke.

Linde Co., div. of Union Carbide Corp., announces plans for construction of a liquid-oxygen plant, to be constructed near the Fort Crowder Reservation, Neosha, Mo. Liquid oxygen will be delivered to the Fort Crowder missile-testing station; thus Linde continues to grasp a firm hold of the liquid rocket fuel industry.

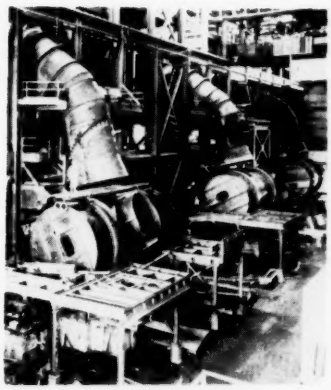
Standard Oil Co. of California has placed on stream the world's first Butamer unit for conversion of normal butane to isobutane. Butamer unit, integrated with a new alkylation unit, was designed by Universal Oil Products.

California Spray Chemical Co. has just begun production of nitric acid at Kennewick, Wash. Nitric acid is used to produce ammonium nitrate fertilizer, is made by ammonia oxidation.

Air Products, Inc., reports that consumption of oxygen by the steel industry is steadily increasing, has doubled since 1955 to its present level of 338

cu. ft./ton steel. Air Products reveals four expansions, costing $33-million, to supply: 340 tons/day to Jones & Laughlin in Pittsburgh, Pa.; 535 tons/day to Jones & Laughlin in Cleveland, Ohio; 170 tons/day to Granite City Steel Co. in Granite City, Ill. and 650 tons/day to Weirton Steel Co. in Weirton, W. Va.

Collier Carbon and Chemical Corp. announces plans for construction of carbon and petroleum chemical production facilities at a newly acquired site near Rodeo, Calif.



International Nickel Co. of Canada, Ltd., is making headway with construction of its giant nickel plant at Thompson, Manitoba (*Chem. Eng.,* Sept. 7, 1959, p. 186). Shown above are converters, just positioned beneath hoods over the converter aisle. Facility, when completed, will be the second largest nickel-producing plant in the world.

Armstrong Cork Co. is reaching for European markets, has formed Armstrong International, S. A., for sale of cork products. Headquarters for sales will be in Geneva.

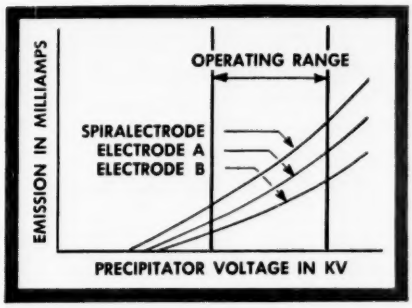
Magnolia Petroleum Co., long a member of the world-wide

1500 miles of Spiralectrodes in Precipitator Service!

That's real proof of superior performance. Over 1500 miles of these emitting electrodes have been installed in 'SF' electric precipitators . . . delivering 50 to 100% more electron emission than conventional types of electrodes.

There are sound reasons why Buell *Spiralectrodes* are providing superior emitting efficiency in actual dust collecting applications.

- *Spiralectrodes* are *"emission engineered"* – pitch and diameter are custom designed for each application . . . of critical importance with high resistivity dust.
- *Spiralectrodes are precision made from stainless steel*– of uniform quality, corrosion-resistant.
- *Spiralectrodes minimize efficiency-loss of dust build-up* –no horizontal surface to collect dust, positive rapping cleans electrodes.
- *Spiralectrodes maintain predetermined tension* – (no weights required) . . . dampen effect of vibration caused by electrical pulsation, thereby minimizing electrode breakage.
- *Spiralectrodes'* controlled area emission stops sparking effect of "point emission."



Above chart illustrates the superior emission of the Spiralectrode: its corona voltage is lower and its emission is higher than other types of emitting electrodes over the entire operating range of industrial precipitator voltage.

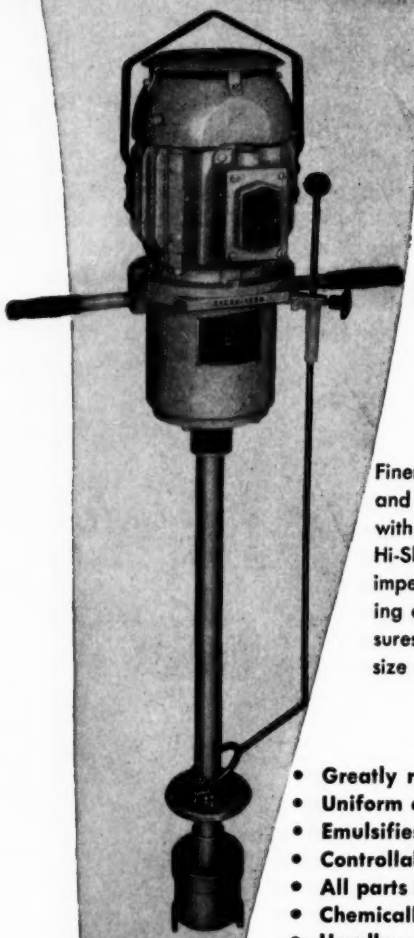
The superior operating characteristics of Spiralectrodes contribute to continued high efficiency of Buell 'SF' Precipitators. Detailed information of this and other exclusive features are described in a booklet, "Buell 'SF' Electric Precipitators." Send for your copy: write Dept. 12-K, Buell Engineering Company, Inc., 123 William Street, New York 38, New York.

buell®

Experts at delivering Extra Efficiency in

DUST COLLECTION SYSTEMS

SHEAR-FLOW



the modern mixer with power shearing

Finer, faster blending, dispersing and homogenizing is now possible with Shear-Flow's new Model RL Hi-Shear Head. Finely spaced dual impellers induce considerable shearing action and high pumping pressures that rapidly reduce particle size for superior material mixtures.

- **Greatly reduces mixing time**
- **Uniform circulation—no vortex**
- **Emulsifies immiscible liquids**
- **Controllable flow pattern**
- **All parts stainless steel**
- **Chemically inert seals**
- **Handles viscous materials with ease**
- **No operating Torque**
- **Disperses, blends, homogenizes**

GABB SPECIAL PRODUCTS INC.
Windsor Locks, Conn.

SHEAR-FLOW
GABB SPECIAL PRODUCTS INC.

☐ Have representative.
☐ Send more information

Name_____

Position_____

Co. & Address_____

FIRMS . . .

Mobile family, announces that it will soon become part of the Mobile Oil Co. The latter is the operating division of Socony Mobile Oil Co., Inc., for the U. S. and Canada.

Chicago Bridge & Iron announces the formation of a new subsidiary, Chicago Bridge (Nederland) N. V., to have its main office in Rotterdam, Netherlands. New subsidiary will erect steel plate primarily for the petroleum industry.

Allis Chalmers Manufacturing Co., Milwaukee, Wis., announces plans for acquisition of the Valley Iron Works Co., of Appleton, Wis. Allis Chalmers thus hopes to strengthen its position in the paper-making industry.

OVERSEAS BRIEFS

Africa: Kaiser Aluminum & Chemical Corp. announces plans to form an international consortium of aluminum companies to build a smelter near the Kosombo and Volta Rivers in Ghana, Africa. Proposals will be submitted by the end of the year. Smelter will be linked to a $4-million hydroelectric plant, to be constructed by Kaiser Engineers on the Volta River.

Pakistan: Burmah Oil Co., California Texas Oil Co., Shell Petroleum Co. and Standard Vacuum Oil Co. have completed negotiations with the Pakistan Government for construction of an oil refinery in Karachi to have a capacity of 1.5-million tons/yr. of crude.

Italy's nuclear energy agency has agreed with Euratom to establish a European research center at its Ispra, Italy, facility. Euratom will invest some $39-million in the laboratories, now worth more than $11-million.

CALENDAR

Canadian Chemical Specialties Manufacturers Assn., annual meeting and convention, Royal York Hotel.
Nov. 2-4 Toronto, Ont.

Atomic Industrial Forum, annual meeting, Sheraton-Park Hotel.
Nov. 2-3 Washington, D. C.

Metallurgical Society, American Institute of Mining, Metallurgical and Petroleum Engineers, National Metals Conference, Morrison Hotel.
Nov. 2-5 Chicago, Ill.

American Society for Metals, annual meeting and congress, International Amphitheatre.
Nov. 2-6 Chicago, Ill.

Industrial Management Society, Industrial Engineering and Management Clinic, Hotel Sherman.
Nov. 4-6 Chicago, Ill.

American Nuclear Society, national meeting, Sheraton Park Hotel.
Nov. 4-6 Washington, D. C.

Technical Assn. of the Pulp and Paper Industry, Alkaline Paper Conference, Robert Meyer Hotel.
Nov. 4-6 Jacksonville, Fla.

Eighth Annual Instrumentation Conference, Louisiana Polytechnic Institute.
Nov. 5-6 Ruston, La.

International Rubber Conference, sponsored by A.S.T.M., A.C.S., and A.S.M.E., Shoreham Hotel.
Nov. 8-13 Washington, D. C.

Chemical Market Research Assn., meeting on consumer chemicals.
Nov. 9-10 Chicago, Ill.

American Petroleum Institute, 39th annual meeting, Palmer House, Conrad-Hilton and Congress Hotels.
Nov. 9-11 Chicago, Ill.

Operations Research Society of America, national meeting, Huntington-Sheraton Hotel.
Nov. 11-13 Pasadena, Calif.

Armour Research Foundation, National Industrial Research Conference, Sherman Hotel.
Nov. 12-13 Chicago, Ill.

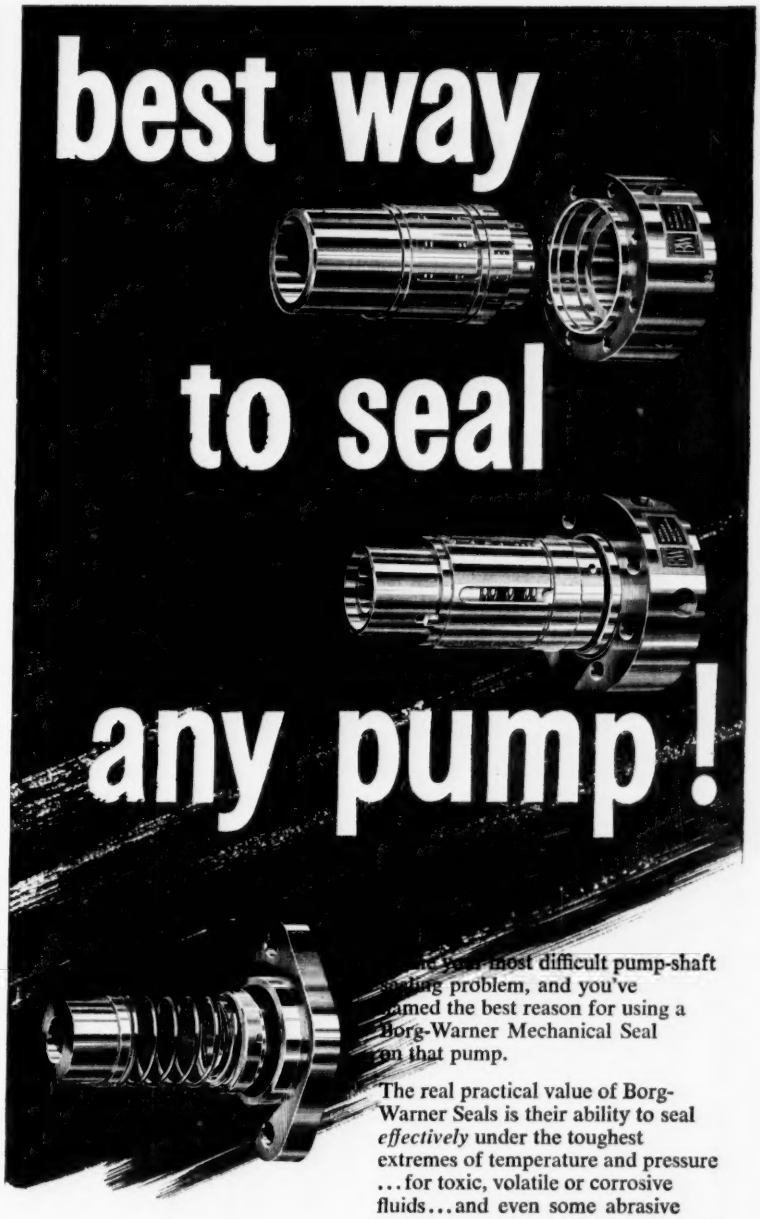
National Academy of Sciences-National Research Council, construction conference, Shoreham Hotel.
Nov. 16-20 Washington, D. C.

Packaging Institute, annual national Packaging Forum, Hotel Statler.
Nov. 16-18 New York, N. Y.

National Assn. of Corrosion Engineers, annual general Florida Conference, corrosion short course.
Nov. 16-20 Miami, Fla.

American Standards Assn., national conference on standards, Sheraton-Cadillac Hotel.
Nov. 18-20 Detroit, Mich.

Society of Plastics Engineers, Technical Conference on plastics in packaging, Claremont Hotel.
Nov. 19 Berkeley, Calif.



...most difficult pump-shaft ...ling problem, and you've ...imed the best reason for using a Borg-Warner Mechanical Seal ...on that pump.

The real practical value of Borg-Warner Seals is their ability to seal *effectively* under the toughest extremes of temperature and pressure ... for toxic, volatile or corrosive fluids ... and even some abrasive liquids. *Result*—less down time, elimination of expensive stuffingbox maintenance, and savings of the pumped fluid.

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Borg-Warner® Mechanical Seals
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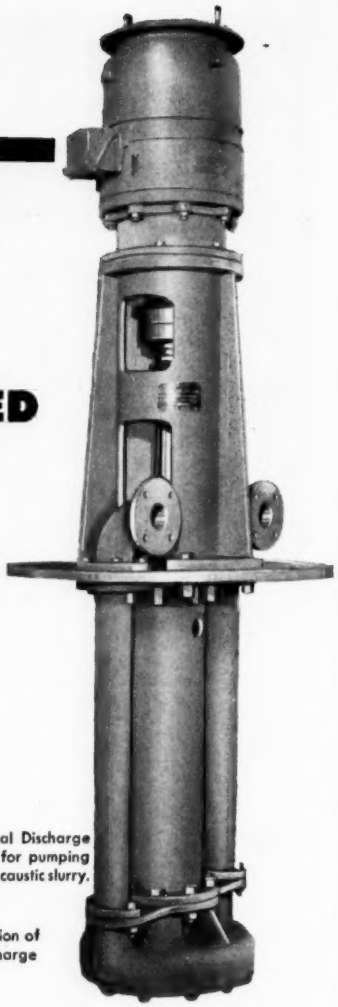
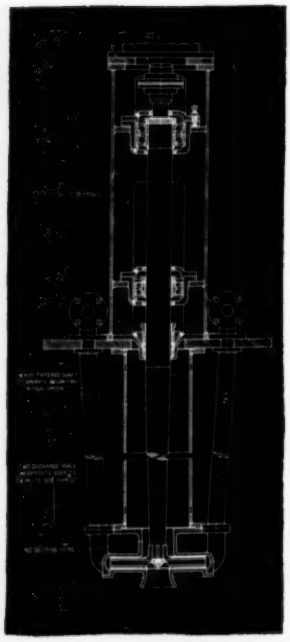
VERTICAL PUMPS WITH NO SUBMERGED BEARINGS FOR PUMPING ABRASIVE CORROSIVE SLURRIES



2" Dual Discharge Pump for pumping molten caustic slurry.

Cross section of Dual Discharge Pump.



This rugged type of service calls for advanced design: — extra heavy shaft, double-ported casing to equalize the side thrust of the impeller, and tough abrasion-corrosion resistant alloys. The dual discharge pump illustrated here incorporates these features and dispenses with bearings or packing below the cover plate where they would be in contact with the liquid.

Difficult pumping problems, particularly in the process industries, have been our specialty for ninety-one years. Perhaps we can be of help to you. Write us — no obligation.

LAWRENCE PUMPS INC.

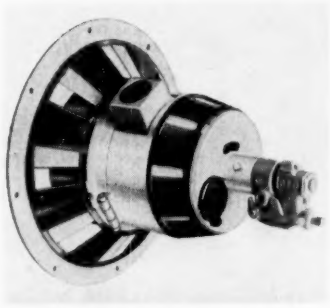
Write for Bulletin 203-7 for Complete summary of acid and chemical pump data.

371 MARKET STREET, LAWRENCE, MASS.

NEW EQUIPMENT . . .

(*continued from p. 54*)

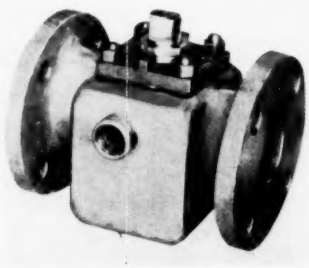
are standard with ratings of 1,000 hp., 3,600 rpm., and above. They are optional with smaller, slower-speed models. Several bearing constructions are available.—**Louis Allis Co., Milwaukee, Wis.** **54E**



Burner

Natural-draft unit for firing process furnaces.

Particularly adapted to the simultaneous firing of oil and gas, the new Flexipro (flexible process) burner is applicable to either vertical or horizontal firing operation. The unit's dual air register provides positive control of air flow, and excellent stability under adverse fuel-air ratios. Capacities vary from 2- to 16-million Btu./hr.—**Peabody Engineering Corp., New York, N. Y.** **130A**



Jacketed Valves

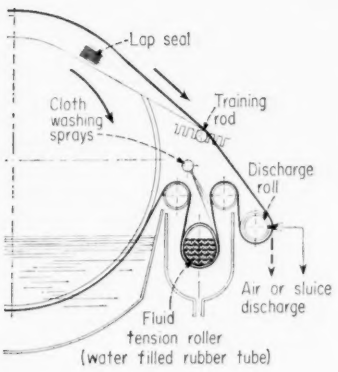
Compact units developed for special applications.

Designed for special applications involving heated or cooled media, particularly where valve performance may be a problem,

a new line of jacketed valves features Teflon-resin expansion sleeves. These components keep the valves tight without readjustment, at the same time allowing for expansion or contraction of the resin over wide temperature and pressure ranges.

An integral jacket surrounding the body permits introduction of heating or cooling media. Adequate clearance is allowed for normal flange bolting with standard flanges.

Offered in two-way and three-way designs, both in 150- and 300-psi. designs, the valves are wrench-operated in sizes from ½ through 3 in., and gear-operated in sizes 3 through 6 in. Material of construction varies with application.—**Continental Manufacturing Co., New York, N. Y.** **130B**



Filter

Rotary unit's fabric medium leaves drum, returns.

A new rotary filter features a mechanism that continuously removes the fabric medium from the drum, washes it thoroughly, and then automatically replaces it on the drum. This action prevents cloth blinding, and makes it possible to discharge thin cakes without blowback. Cloth life is extended because there is no scraper abrasion and no cutting caused by particles held in the medium's threads.

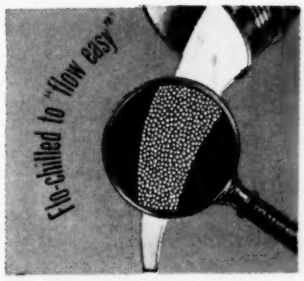
A water-filled, flexible rubber tube keeps the medium on track and under tension. Solution or air jets directly under the cloth

Why did we send this drum of caustic on a winter cruise?

This is our way of reminding you that the caustic that flows *best* in the summer is, of course, the caustic you should use in the winter, too.

If you're one of the many who were prudent enough to use Wyandotte Flo-chilled Anhydrous Caustic Soda last summer – you know what we mean. *It's free-flowing always.*

Call your Wyandotte representative or distributor NOW. It costs no more than ordinary caustic.



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Wyandotte CHEMICALS

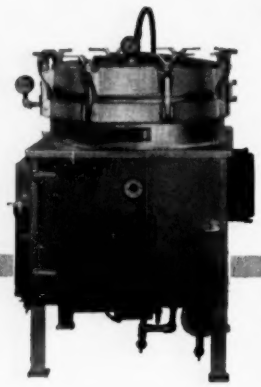
MICHIGAN ALKALI DIVISION

WYANDOTTE CHEMICALS CORPORATION, WYANDOTTE, MICHIGAN • Offices in Principal Cities

LOWER YOUR VACUUM PUMP MAINTENANCE COSTS

with a

HILCO OIL RECLAIMER



HILCO Oil Reclaimer purifies vacuum pump oil by continuous recirculation, either on a full-flow or by-pass basis, or intermittently on a batch basis, depending on the requirements and physical layout of your plant.

HILCO OIL RECLAIMER SYSTEMS are the finest available for VACUUM PUMP users . . .

A simple, economical and efficient method of restoring contaminated lubricating and sealing oil to the full value of new oil. A HILCO will produce and maintain oil free of all solids, sludge, acid, moisture, solvents, and dissolved gases and it will restore viscosity, dielectric strength and other specifications to new oil value. HILCO oil reclaimers are in wide use for purification of vacuum pump oil in many manufacturing operations.

• SPECIAL FEATURES •

THERE'S A HILCO FOR EVERY OIL PURIFICATION JOB . . .

- CONTINUOUS, ALL ELECTRIC, AUTOMATIC OPERATION
- LOW OPERATING TEMPERATURE
- VACUUM PROCESSING
- LOWERS VACUUM PROCESSING COSTS

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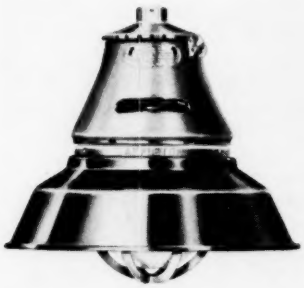
discharges cake. A zipper speeds replacement of media when required.—**Peterson Filters and Engineering Co., Salt Lake City, Utah.** **131A**

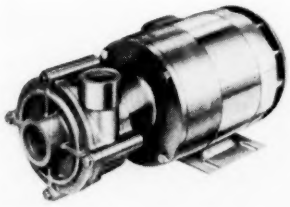


Lighting Fixture

Mercury lamp gives more light at a lower cost.

When explosion-proof equipment is a "must" and the cost of lighting is a serious consideration, the new AA-51 mercury vapor lamp could win ready acceptance. According to the manufacturer, statistics confirm that the fixture gives 2½ times as much light as normal.

With 250-w. lamps, either clear or color-corrected fixtures are available; with 400-w. units, clear, color-corrected or silver-white types are offered. Wide choice of mountings, reflectors, globes and guards. — **Appleton Electric Co., Chicago, Ill.** **132A**



Centrifugal Pump

Has a minimum of moving parts, and no bearings.

Body, face plate and impeller of a new centrifugal pump are made of chemically resistant Cycolac plastic. Or, on special order, material of construction may be any substance that can

Now U.S. hones gears to superfinish

HOBBING gears is like SAWING WOOD. All gears are hobbed.

SHAVING gears is like PLANING. Some makers shave gears.

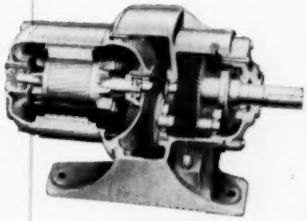
for: SMOOTHNESS QUIET RUNNING LONGER LIFE

another reason to specify:

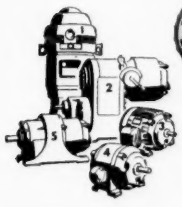
U.S. Syncrogear Motors

Among the makers of electric gearmotors, only one – U.S. Motors – *hones* gears to assure extremely accurate profile and smoothness. This honing means quiet running and longer life. Gear hobbing, the necessary first step in cutting gear teeth, leaves a degree of roughness analogous to sawing wood. Many gear makers go no further. Some, however, shave the gear teeth before hardening. This leaves a surface analogous to planing wood.

The ultimate refinement in tooth profiling, however, is honing – which may be likened to sanding of wood. This takes place *after* gear teeth are hardened. Thus, it takes out any imperfections and minor heat-treat distortions. It is to assure precision and exclusive refinements such as this that U.S. makes its own gears. Another good reason to specify: "U. S. SYNCROGEAR MOTORS." (⅓ to 50 H.P.)



SEND FOR FREE SYNCROGEAR MOTOR BROCHURE No. F-1880, *explaining the Syncrogear principle. Color illustrated.*



U.S. ELECTRICAL MOTORS INC.

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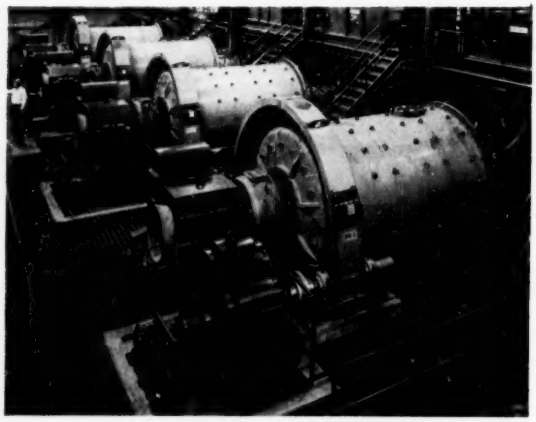
LOS ANGELES 54, CALIFORNIA
OR MILFORD, CONNECTICUT

U.S. MAJOR MOTOR LINES INCLUDE:
1. Vertical Solid & Hollowshaft, **2.** Varidrive, **3.** Totally-Enclosed, **4.** Uniclosed, **5.** Syncrogear. Also, many other special motors.

Marcy Grinding Mills

for the Chemical Industry

- center and end peripheral discharge rod mills, open end rod mills, grate discharge ball mills, tube mills, pebble mills, acid-proof mills, batch mills.
- wet or dry grinding.
- 29 different diameter sizes, from 12" to 12'6" inside diameter, are operating and proved in the field.
- grind material 1½" or finer to a product as fine as 325 mesh.
- capacities up to 6650 tons per 24 hours.



Typical Marcy Ball Mill Installation

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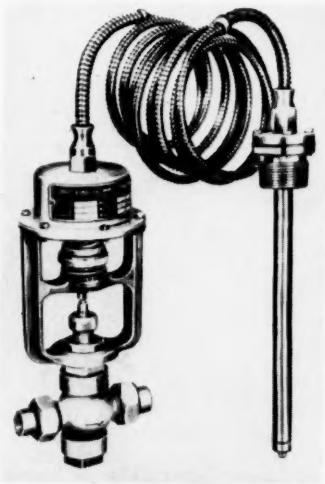
be injection-molded. This highly efficient unit, for continuous duty with corrosive liquids, will deliver up to 33 gpm. against heads to 28 ft.

Shaft and couplings are 316 stainless steel. Motor casing is aluminum. The rotary mechanical seal, made of Graphitar, assures permanent low-drip sealing that requires no adjustment. **—Houston Fearless Corp., Los Angeles, Calif. 132B**



Temperature Regulator

For heating, cooling. Are vapor-pressure operated.

Designated Type TC or TCX, a new series of regulators will control the flow of either heating or cooling fluids. Temperature range for TC units is 25 to 385 F., in 40-deg. increments. Temperature span for TCX models is 50 to 310 F., in 70-deg. increments.

Body sizes for both groups vary from ¼ to 2 in. for bronze construction with union connections. Type TC is also available with 125-psi. ASA flanged ends in sizes from 2½ to 5 in.—**A. W. Cash Valve Mfg. Corp., Decatur, Ill. 134A**

BRIEFS

Flow switch provides positive indication of flow, loss of flow, or excessive flow of any

liquid or gas in a pipeline. Known as the Model FS-200M, the switch operates on a very low pressure differential, and can be installed in any pipeline with ordinary tools. Standard sizes to 3 in.—**The Gems Co., Inc., Newington, Conn.** 134B

Column packing knitted of nylon monofilaments is available for applications where contact with metals must be avoided, and for cases where metals of suitable corrosion resistance would be more expensive.—**Packed Column Corp., New York, N. Y.** 135A

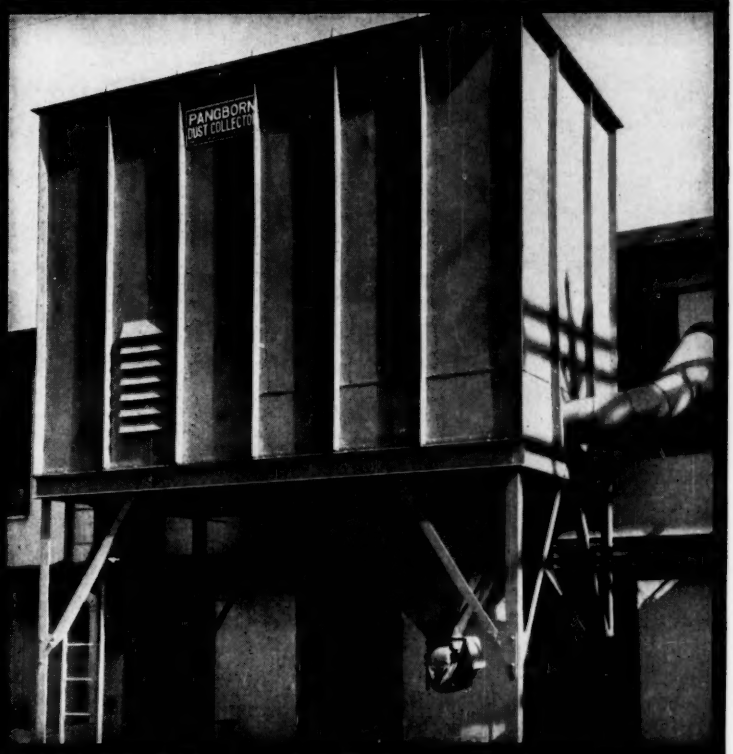
Vertical drive agitators have an output-shaft bearing assembly that provides maximum rigidity and minimum shaft deflection. Run-out or deflection at the center of the seal or stuffing box is controlled within close limits to virtually eliminate wear at this critical point. Designed for pressures to 2,500 psi., the line comes in sizes from 3 to 60 hp., in a wide range of speeds.—**U. S. Mixer Div., Stockdale Engineering Co., Haddonfield, N. J.** 135B

Equipment Cost Indexes . . .

	March 1959	June 1959
Industry		
Avg. of all.....	232.6	234.3
Process Industries		
Cement mfg.	225.8	227.9
Chemical	233.7	235.7
Clay products	219.4	221.5
Glass mfg.	220.7	222.5
Paint mfg.	224.4	226.6
Paper mfg.	225.2	227.1
Petroleum ind.	229.2	231.4
Rubber ind.	232.0	234.0
Process ind. avg....	230.1	232.8
Related Industries		
Elec. power equip...	236.5	246.7
Mining, milling	235.2	237.1
Refrigerating	262.2	264.7
Steam power	219.7	221.8

Compiled quarterly by Marshall and Stevens, Inc., of Ill., Chicago for 47 different industries. See Chem. Eng., Nov. 1947, pp. 124—6 for method of obtaining index numbers; Feb. 23, 1959, pp. 149-50 for annual averages since 1913.

TRAPS ALMOST 4 CU. FT. OF DUST PER WEEK



One small Pangborn Dust Control system replaces 8 collector units profitably at Precision Rubber Products

At Precision Rubber Products Corporation, Dayton, Ohio, millions of seals pass through a buffing process every year. The resulting dust could constitute an operating and housekeeping hazard. To facilitate dust control, the company replaced eight individual collector units with a central Pangborn Dust Control system. This installation saves floor space, operates quietly and gives efficient dust control (trapping almost 4 cu. ft. of rubber dust per week). Dust is now removed from *one* collector hopper instead of eight individual hoppers.

If dust is a problem in your plant, talk to the Pangborn man in your area or write PANGBORN CORPORATION, 2600 Pangborn Blvd., Hagerstown, Md. *Manufacturers of Dust Control and Blast Cleaning Equipment—Rotoblast® Steel Shot and Grit.*

Pangborn CONTROLS DUST

DAY

Pneumatic Conveying & Bulk Storage News

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BULLETIN M-588—12 page DAY pneumatic conveying guide just off the press. Discusses types of systems, illustrates and diagrams high and low density arrangements, shows equipment and tells "why" and "wherefore" of all types of pneumatic conveying including so-called fluidizing systems.

BULLETIN 574—12 pages, describes horizontal and vertical storage tanks. Points out savings and is filled with photos of various installations plus description of auxiliary equipment.

Whatever your pneumatic conveying or bulk storage problem, look first in these DAY bulletins. They are valuable aids in selecting and ordering the right equipment for your plant. For your free copies use reader service card of this magazine or write direct toDAY.

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TECHNICAL

A Strong Plea:

". . . for the use of these analytical techniques by the experimentalist himself, rather than by a professional statistician." — Foreman S. Acton in his preface to . . .

ANALYSIS OF STRAIGHT-LINE DATA. By Forman S. Acton. John Wiley & Sons, Inc., New York. 267 pages. $9.

Reviewed by Leon Cooper, Research and Engineering Division, Monsanto Chemical Co., St. Louis, Mo.

"Analysis of Straight-Line Data" is a book that deals primarily with a single aspect of statistics that is of importance to engineers and scientists—namely, the analysis of experimental data that can be expressed by means of linear relationships. Furthermore, the author is a strong proponent of the philosophy which holds that the experimentalist, rather than the professional statistician, should select the methods of statistical analysis and carry out the required analyses. His book, then, is not a textbook, but is a practical exposition of this area of statistics for the engineer and scientist who can learn for himself the important techniques and difficulties involved when he attempts to analyze his data.

The first six chapters explain these techniques and contain excellent examples of real data as well as sample calculations. The writing is clear and informed. The author relies heavily on heuristic arguments rather than mathematical rigor, but in view of his objective this is justified. He does not gloss over difficulties in theory or application.

The last few chapters are concerned with the use of polynomials when a straight-line analysis will not suffice and with

BOOKSHELF

J. B. BACON

several problems which have always plagued experimentalists. The relevant questions are highlighted and some of the answers which have been advanced are discussed.

This book can be recommended as being of great value to the engineer faced with data analysis problems. In addition to being informed he will find the book a real pleasure to read.

BRIEFLY NOTED

ANALYSIS OF WATER EMULSION PAINTS. 7 *pp. By M. E. Swann, Coating Chemical Laboratory, Aberdeen Proving Ground, U. S. Army. Order PB* 151687 *from Office of Technical Services, U. S. Department of Commerce, Washington* 25, *D. C.* 50¢. Describes a method of separating pigments from polymer portion of paints for complete analysis of this type of coating.

ANNOTATED BIBLIOGRAPHY ON THE USE OF ORGANOLITHIUM COMPOUNDS IN ORGANIC SYNTHESIS, Supplement No. 6; 328 abstracts. *Lithium Corp. of America. Gerald A. Munson, Director, Tech-Service Div., Lithium Corporation of America,* 1100 *Title Insurance Bldg., Minneapolis* 1, *Minn.* $2. Brings the total to 1,800 abstracts published since 1949.

APPLICATION OF ANALOG COMPUTERS TO VARIOUS COMBUSTION, FLAME and FLUID DYNAMICS PROBLEMS. 64 *pp. By T. J. Williams, Wright Air Development Center, U. S. Air Force. Order PB* 151775 *from Office of Technical Services, U. S. Department of Commerce, Washington* 25, *D. C.* $1.75. Describes use of analog computer on such problems as solution of the equations of the steady-state laminar flame, the unsteady-state laminar flame, flame phenomena in turbulent flow and other problems.

Here's a real cost-saving idea!

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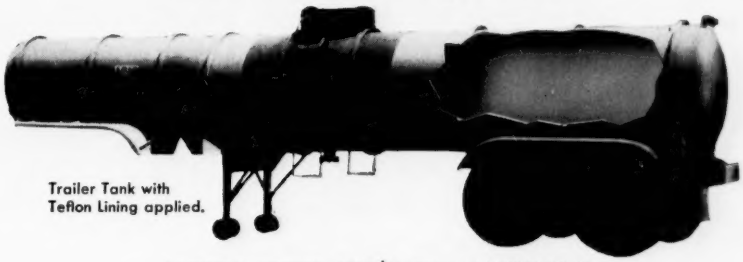

Trailer Tank with Teflon Lining applied.

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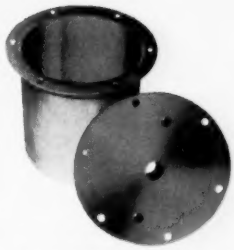
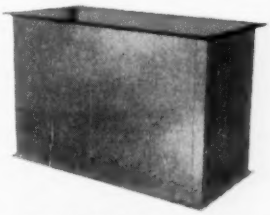
LINCO, INC., Houston, Texas
MERCER RUBBER CORP., Little Ferry, N. J.
METALWELD, INC., Philadelphia, Pa.

Or, write for information, Special Products Dept., United States Gasket Company, Camden 1, New Jersey.

*DuPont Trademark for TFE Fluorocarbon Resins



Reactor Pot lined with Teflon.

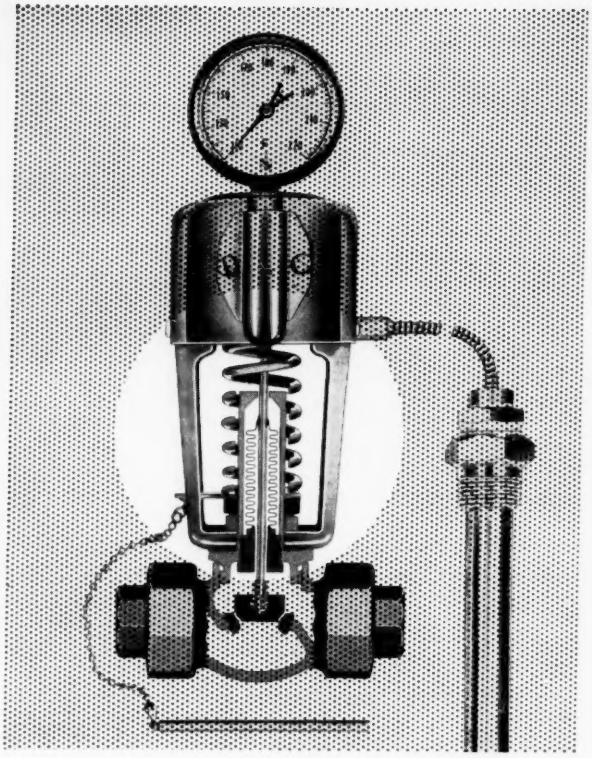


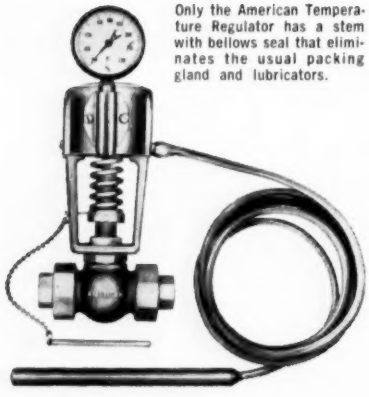
Fluoride Tank lined with Teflon.

Pipe Coupling with Teflon Linings.

United States Gasket Plastics Division of GARLOCK

Temperature Regulation with Corrective Action within 1/10 of a degree





Only the American Temperature Regulator has a stem with bellows seal that eliminates the usual packing gland and lubricators.

A friction-free bellows seals off the valve stem on the new American Temperature Regulator. Result: no stem binding to retard valve action, fastest possible temperature response.

The bellows seal makes practical a friction-free, nonleaking packless valve that needs no lubrication. This innovation plus an extra-long, preflexed adjusting spring marks the new American Temperature Regulator as the fastest acting, most stable available. Corrective action starts at less than 1/10 degree change at the bulb. And the adjusting spring allows unusual latitude in temperature settings.

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Get the best in economy, accurate temperature regulation, and dependability. Choose American Temperature Regulators. *Sizes:* ½" to 1½". *Temperature Ranges:* As low as minus 15°F. to 50°F.–as high as 240F°. to 350°F. *Valve:* Bronze body, stainless steel seat and disc. *Ask for Bulletin 114A.*

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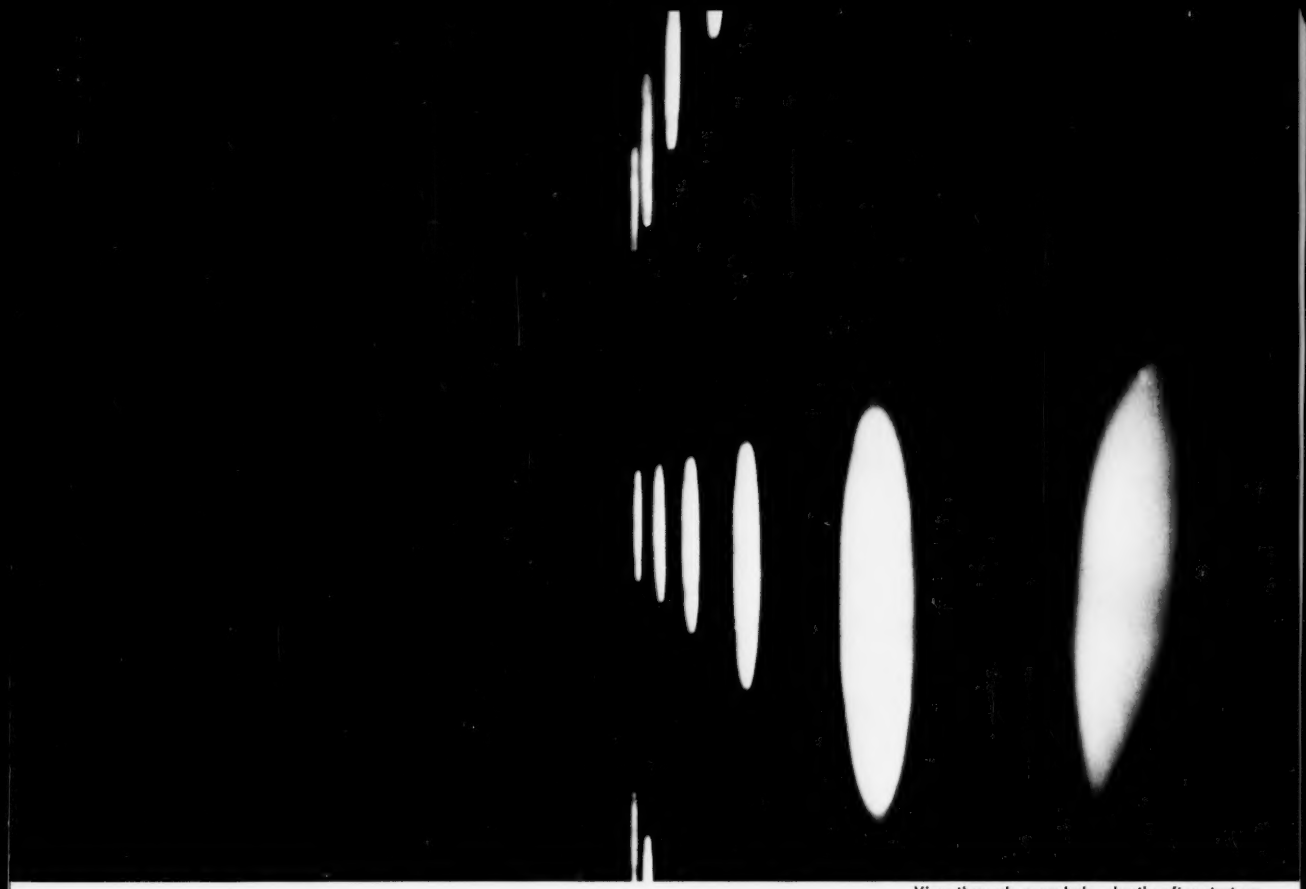

View through peep-hole, shortly after start-up.

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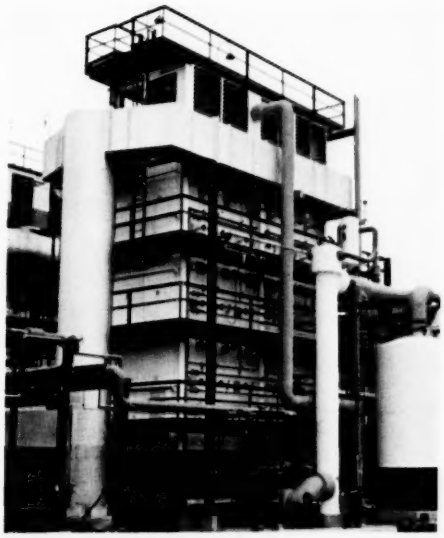

Selas Steam-Methane Reforming Furnace at Collier Carbon and Chemical Corporation, Brea, California. Duradiant burners patterned in seven horizontal rows are individually adjustable, respond instantly to heat input required, burn with extremely low excess air (6%).

A look inside this new Selas Steam-Methane Reforming furnace at the Collier Carbon and Chemical Corporation, Brea, Calif., plant, clearly demonstrates the benefits of Gradiation heating for petroleum, petrochemical and chemical processing:

PRECISENESS OF HEATING . . complete combustion within Duradiant® burner cup permits placing burners close to tubes . . achieving fast heat-up and instantaneous response to controller demand.

HEAT UNIFORMITY . . even-heat distribution along and around tubes increases tube life by eliminating hot spots, minimizing coke formation.

ZONE CONTROL . . Duradiant burners can be adjusted to desired heat pattern in either horizontal or vertical rows.

VERSATILITY . . Gradiation heaters can handle a variety of feedstocks, interchangeably, under optimum conditions.

These benefits apply to *horizontal,* as well as *vertical,* Gradiation tubular furnaces.

May we arrange for a Selas field engineer to discuss your heat processing needs with you? For this service . . without cost or obligation to you . . or for a copy of Bulletin 1043C "Gradiation Heating for Petroleum and Chemical Processing," write to Mr. K. W. Fleischer, vice president, Fluid Processing Div., Selas Corporation of America, Dresher, Pa.

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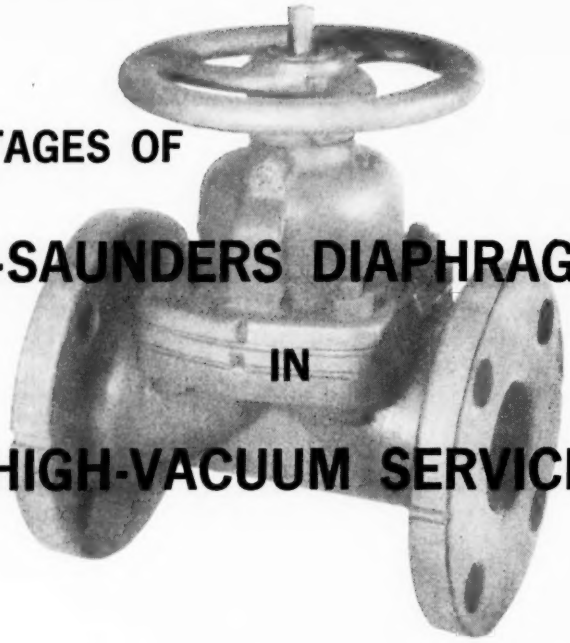
CORPORATION OF AMERICA
DRESHER, PENNSYLVANIA

Heat and Fluid Processing Engineers

DEVELOPMENT • DESIGN • CONSTRUCTION

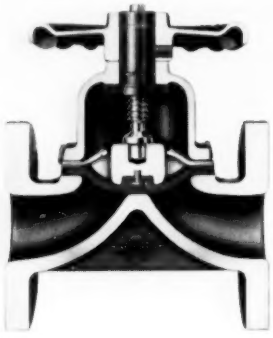
GRINNELL REPORTS ON VALVES:

THE ADVANTAGES OF GRINNELL-SAUNDERS DIAPHRAGM VALVES IN HIGH-VACUUM SERVICE



Dependable performance and long service life for vacuums down to 0.1 micron . . . with leak rates of less than 0.1 micron cubic foot/hour

One of the most important requirements of valves for high-vacuum service is that they must be vacuum-tight at all times during their operating cycle. Diaphragm valves of the Grinnell-Saunders manufacture fully meet this requirement. When clamped between the flanges of the body and bonnet, the diaphragm is easily made vacuum-tight down to 0.1 micron — with an in-leakage rate of less than 0.1 micron cubic foot/hour. Whether in the open, throttling or closed position, the diaphragm presents a smooth, unbroken face to the vacuum side of the chamber.



Valve provides vacuum-tight seal in closed position

Rugged, nylon-reinforced diaphragms in a variety of materials

Grinnell has perfected a method of reinforcing its diaphragms with wear-resistant nylon. The result is a diaphragm that lasts longer at high-vacuum. The only part of the valve subject to service wear at any time is the diaphragm — which can easily be replaced in a matter of minutes, without removing the valve body from the system. Diaphragms are available in a wide choice of materials.

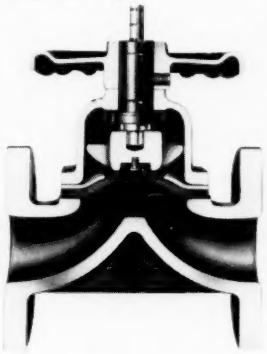
Rugged, reinforced nylon diaphragm gives long-lasting life

Contamination minimized

Construction of Grinnell-Saunders Diaphragm Valves provides separation of the working mechanism from the vacuum within the system. This isolation of lubricated working parts prevents contamination of the system from lubricant outgassing.

Large, unimpeded valve passage

The large passage of the Grinnell valve, in the open position, offers minimum impedance to the escape of random moving molecules in pumping down to high-vacuum, thus shortening the pump-down cycle.



In open position, valve passage is free and unimpeded

Special provisions:

Sealed bonnets are available for evacuation when required. Elastomer type diaphragms do not require evacuation of the bonnet. Valves with plastic diaphragms, used at elevated temperatures, do require evacuation of the bonnet for long diaphragm service life.

For more information

Get further facts about Grinnell-Saunders Diaphragm Valves. Learn, how the diaphragm lifts high for streamline flow in either direction . . . and how the diaphragm seals firmly against the body weir for leak-tight closure. Write to: — Grinnell Company, Providence 1, Rhode Island.

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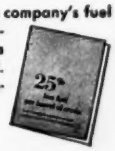
Hotter combustion air can boost the output of a pipe still, too—by as much as 25%. Or, it can cut your fuel bill by an equal amount—or permit you to use cheaper fuels that were previously considered useless. And whatever fuel you use, there's less slag, fewer deposits, because a Ljungstrom Air Preheater helps burn fuel more completely. Some plants have "written off" the cost of their Ljungstroms *in only nine months.*

Here's documented evidence. One company's fuel savings with a Ljungstrom Air Preheater are factually described in a published magazine article by O. F. Campbell. A reprint of this case history is yours free. Simply write:



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LETTERS:

Patent Clarification

Sir:

In your report of our new grease patent (July 13, p. 98), we feel the last paragraph was not sufficiently specific and may create a wrong impression. To clarify this particular paragraph, it should read as follows:

Manufacturers purchasing the soap made with sebacic acid as one of the components from Witco or its licensees, according to Patent 2,699,428, may market the grease produced therefrom without the payment of royalties.

S. K. FRIEDMAN
Witco Chemical Co.
New York 17, N. Y.

Re: Scientific Words

Sir:

In the exchange of letters following Rudolf Flesch's article on "Better English," Dr. Flesch says (Aug. 24, p. 184):

"The giveaway, it seems to me, is the word 'mediocre' that occurs in several of the letters. It is certainly not a scientific word, but rather a term of snobbery."

Is "snobbery" a scientific word?

I have read some of Dr. Flesch's work and admire it.
But if a teacher teach too well,
He'll find his pupils soon can tell
Him where he's made mistakes himsel',
But only if he teach too well.

ROBERT P. COURTNEY
Normal, Ill.

Sir:

My reaction to Dr. Flesch's article (Apr. 20, pp. 188-194) is one of astonishment tinged with amusement and a dash of indignation.

A basic contradiction in the article has apparently been missed by your other correspondents. Dr. Flesch says, "If you want to improve your English you must first of all learn to relax." But in the paragraph immediately preceding he says, "It seems easy to avoid the pompous, but actu-

PRO & CON

C. H. CHILTON

ally it's extremely difficult." How can one be relaxed while doing that which is "extremely difficult"?

BEATRICE PEARSON

Chicago, Ill.

Foreign Equipment Costs

Sir:

We have found that a well-built plate heat exchanger is available at approximately 30% of the cost figures shown in your *CE* Cost File (June 29, p. 112).

Based on complete specifications for a heat-exchange problem involving two triethylene glycol streams, firm quotations from two U. S. manufacturers were $26,900 and $28,610. Another U. S. manufacturer gave us a verbal quote of $27,200.

A Swedish concern, however, quoted a price of $8,950, fob. Boston. This unit was carefully checked prior to purchase with references furnished by other customers. The unit is installed and performing perfectly. Inlet pressure is 60 psi., with no leakage along the seals. The quality of the workmanship is excellent.

The purchased exchanger has a total surface of 1,236 sq. ft. Its unit cost of $7.25/sq. ft. is completely out of the range of your Cost File.

We are fully aware of the disadvantages of purchasing foreign equipment. First and foremost are the adverse effects on the economy of the country as a whole. Secondly are other disadvantages, such as spare parts availability, lack of service, metric dimensions, odd flange and thread sizes, etc.

A small difference in the price of domestic vs. foreign equipment may certainly be overlooked in most cases to favor the domestic manufacturer. However, a cost factor of better than three, in this particular case, could certainly not be passed by.

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—, Mass.

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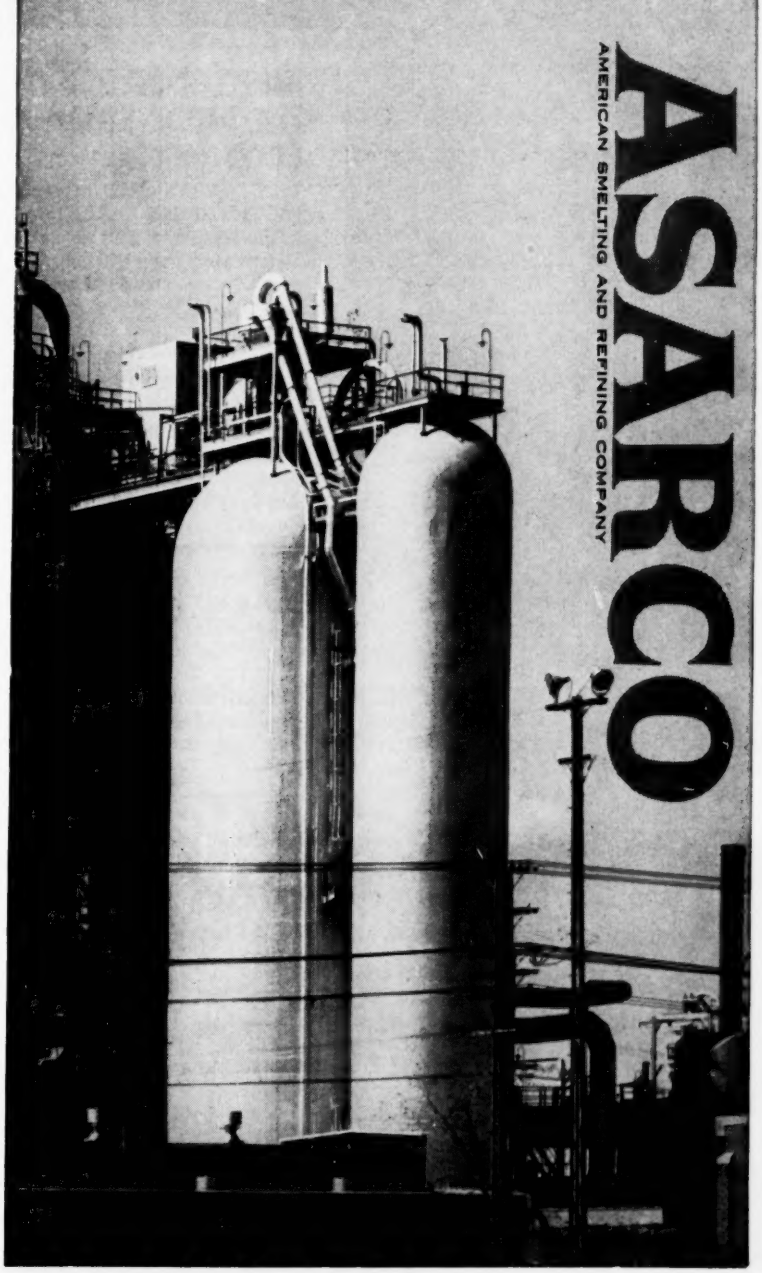
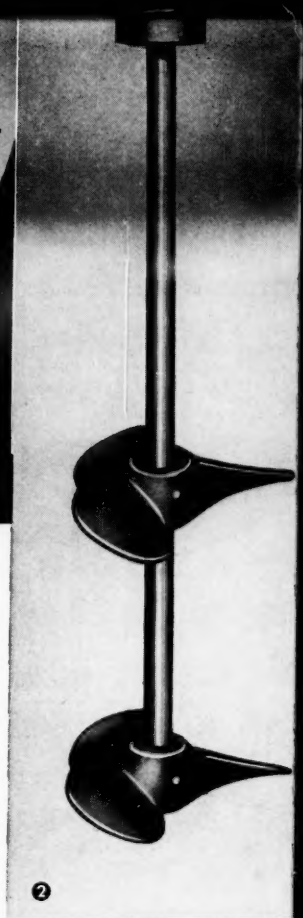
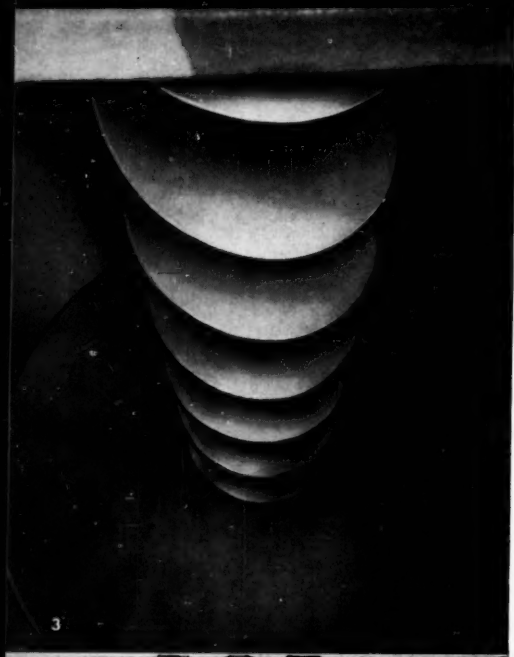
FEDERATED METALS DIVISION OF



Improved Processing through Engineered Agitation





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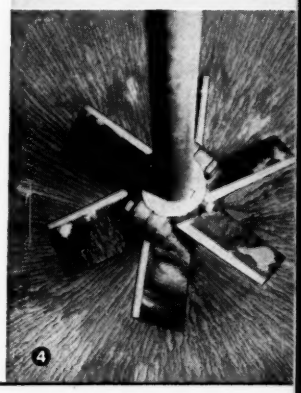

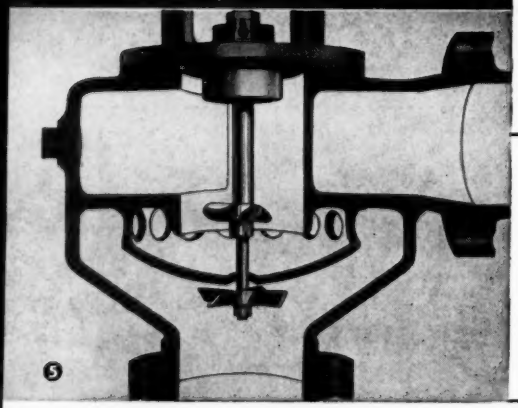

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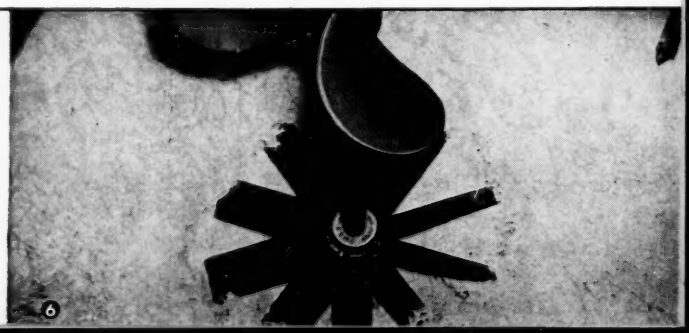

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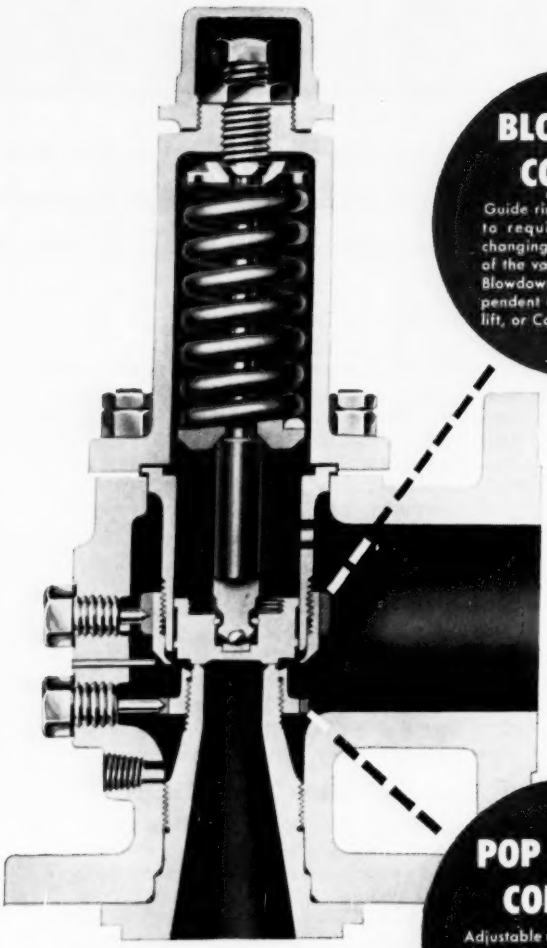
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Chemicals

Adhesives.....4 p. bulletin A-1 contains tabular data describing companies Hysol line of adhesives, most of which are epoxy compounds. Heat cure and RTC varieties.
148A Houghton Laboratories Inc.

Borohydrides.....offer many new processing applications. Qualified technical service in applying the borohydrides to your process is now available.
43 *Metal Hydrides, Inc.

Chemicals.....1959-1960 edition of general catalog, 44 p. lists properties & uses of 375 industrial, pharmaceutical, agricultural chemicals currently produced.
148B Dow Chemical Co.

Chemicals.....A 16 page booklet lists the many chemicals available, such as; vinyl stabilizers, fluorides, glycerine, synthetic optical crystals, fungicides, etc.
47 *The Harshaw Chemical Co.

Chemicals, Custom-Made.....8 p. booklet describes biochemical & chemical facilities for custom production. Nine unit processes are available.
148C Commercial Solvents Corp.

Chemicals, Industrial....."Diamond Chemicals for Industry" covers 200 chemicals in 75 p. Cross references & indexes show their application in various industries.
148D . Diamond Alkali Co

Dihydropyran.....13 p. bulletin 137 describes newly available 2, 3-dihydro-4 H-pyran. Gives physical & chemical properties, details on various types of reactions.
148E Quaker Oats Co.

Dispersants.....The chemical & physical characteristics of Marasperses plus other technical data is covered in Bulletin No. 125. Other Lignosulfonates are listed.
148F Marathon Div. of American Can

* From advertisement, this issue

LITERATURE

E. M. FLYNN

Elastomer.....Gum properties and properties of Vulcanizates plus methods of fabrication and applications for Kel-F Elastomer are contained in a new bulletin.
149A Minnesota Mining & Mfg. Co.

Epoxy Surfacing.....A skid-proof, slip-proof surfacing application utilizing emery aggregate and epoxy resin is described in 2 p. illustrated flyer.
149B Walter Maguire Co.

Ethylene Oxide.....48 page manual brings up to date available information on physical & chemical properties, specifications, analytical procedures, and industrial uses.
149C General Aniline & Film

Glass Fabrics.....2 p. data sheet contains description and typical properties on stock item silicone rubber coated fabrics for many applications.
149D Connecticut Hard Rubber Co.

Heavy Liquids.....12p. "Heavy Liquids for Sink-Float Density Determinations in Quality Control & Research" describes both organic and aqueous liquids.
149E Engineered Materials

Halofluorocarbon Polymers.....Structure, properties & applications of Kel-F Halofluorocarbon Polymers are covered in a technical data sheet. Includes charts & tables.
149F Minnesota Mining & Mfg. Co.

Levulinic Acid.....a particularly interesting chemical with polyfunctional characteristics. Acts both as a crboxylic acid & as a ketone. A new Bul. 301-A, is offered.
39 *The Quaker Oats Co., Chem. Div.

Lubricants.....Organized lubrication as a means of controlling costs, is discussed from management's point of view in a booklet. Discusses methods that cut downtime.
113 *Texaco, Inc.

Mineral Products.....8 p. booklet presents properties of aluminum silicate pigments, Attapulgus clays, activated bauxites and limestone products.
149G Minerals & Chemicals Corp.

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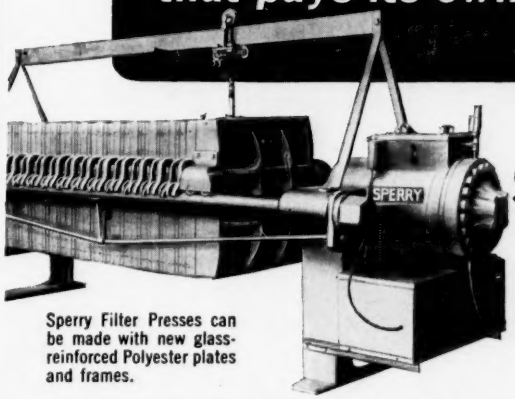

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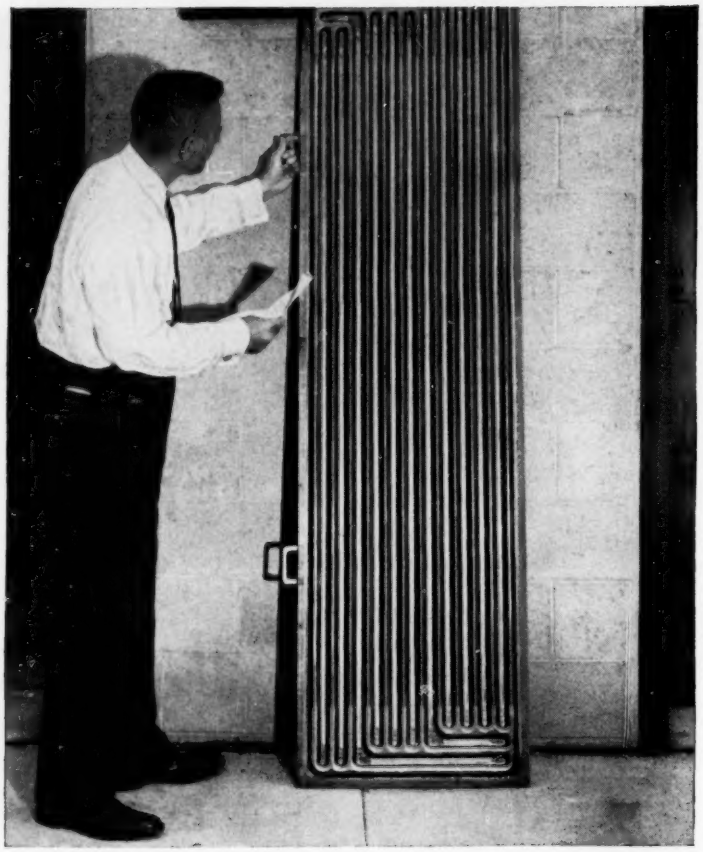

Pressure-tested Ni-o-nel alloy Platecoil® are now being produced in all standard forms and dimensions. See text below for details.

How to heat up destructive corrosives fast... with Platecoil® units made of Inco's new Ni-o-nel* alloy...

...high heat transfer with field-proven resistance to certain hot acids and oxidizing chemicals

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What corrosives are handled by Ni-o-nel?

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Phosphoric acid. Ni-o-nel alloy is one of the most useful materials available for equipment in the production and handling of wet process phosphoric acid. It has given from 2 to 6 times the service of other resistant alloys in such items as reactor tanks, heat exchangers, parts of defluorination systems, and evaporator baffle plates, cylinder and dip pipes.

Nitric acid mixtures. Ni-o-nel alloy is resistant to nitric acid solutions of practically all temperatures and concentrations and shows promise for handling such mixtures as nitric-sulfuric, nitric-phosphoric and some nitric-hydrofluoric acid solutions.

Organic acids. The alloy is resistant to most organic acids and has excellent resistance to boiling concentrated acetic acid, acetic-formic mixtures, maleic and phthalic acid and a number of others.

Sea water and chlorides. This alloy not only resists a wide range of chemical corrosives but also certain troublesome salt cooling waters, making it particularly adaptable for heat exchanger equipment. It resists pitting in salt water and has excellent resistance to stress-corrosion cracking.

For more information...

If you would like engineering specifications on Platecoil® made of Ni-o-nel alloy, write Tranter Manufacturing, Inc., Lansing 9, Michigan. To learn more about the properties of Ni-o-nel alloy, write Inco for "Engineering Properties of Ni-o-nel."

*Inco trademark

What Platecoil® are

Tranter Platecoil® are two 14- or 16-gauge metal sheets (one or both embossed) which are seam or spot welded together to form channels for heating or cooling media. They provide a low-weight, large heat-transfer surface in small space.

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LITERATURE . . .

Nitrogen Tetroxide.....can be used in the wood pulping, rubber, metal recovery & lubricant purification industries. A 59-pg. bulletin gives information & application data.
41 *Allied Chemical, Nitrogen Div.

Organic Chemicals, Aliphatic..... 10 p. booklet lists specifications and chemical composition of long and short chain fatty acids, oleic and unsaturated fatty acid.
151A Armour Industrial Chemical

Pearl Essence.....8 p. guide to the use of natural pearly essence and synthetic pearl pigments. Discusses dispersion and orientation of pearl crystals, choice of types.
151B Mearly Corp.

Pharmaceuticals.....11 p. report on a new drug, triparanol, suggested as an approach to controlling cholesterol bioproduction, contributing cause of heart disease.
151C Wm. S. Merrell Co.

Phenolics.....16 p. "Facts on Phenolics" lists physical properties of 33 Durez phenolic and 3 Durez diallyl phthalate molding compounds. Photos illustrate molded products.
151D Hooker Chemical Corp.

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151E Chemore Corp.

Primer, Red Lead.....Summary test results and a formulation for a new red lead-coumarone primer for seawater immersion are covers in 4 p. Red Lead Technical Letter No. 14.
151F Lead Industries Assn.

Radiochemicals.....20 p. catalog, Schedule E, describes available radioactive compounds, radiation sources, radioactivity standards, radiation source kits.
151G Nuclear-Chicago Corp.

Reagents.....365 p. book, free to qualified laboratories, describes 7,000-plus chemicals in one alphabetical listing. All ACS specified reagents are included.
151H Fisher Scientific Co.

Resin.....Epon 828 resin polymer combines outstanding uniformity with many other desirable properties. Used in the manufacture of many products. Details.
Cover *Shell Chemical Corp.

Silicone Rubber.....12 p. bulletin, CDS-170A, contains product and application data on family of room temperature vulcanizing silicone rubber compounds.
151I General Electric Co.

Solvent.....Solvesso Xylol offers purity & uniformity for many types of surface coatings. Further information or technical assistance on request.
37 *Esso Standard Oil Co.

Sulfuric Acid.....1 p. oleum-sulfuric acid blending chart is intended as an aid in projecting and obtaining desired concentrations from those available.
151J Bacon Chemical Industries

Titanium Powder Metallurgy.....Information about the growing use of titanium powder metallurgy for corrosion-resisting, light, strong parts is now available.
125 *Union Carbide Metals Co.

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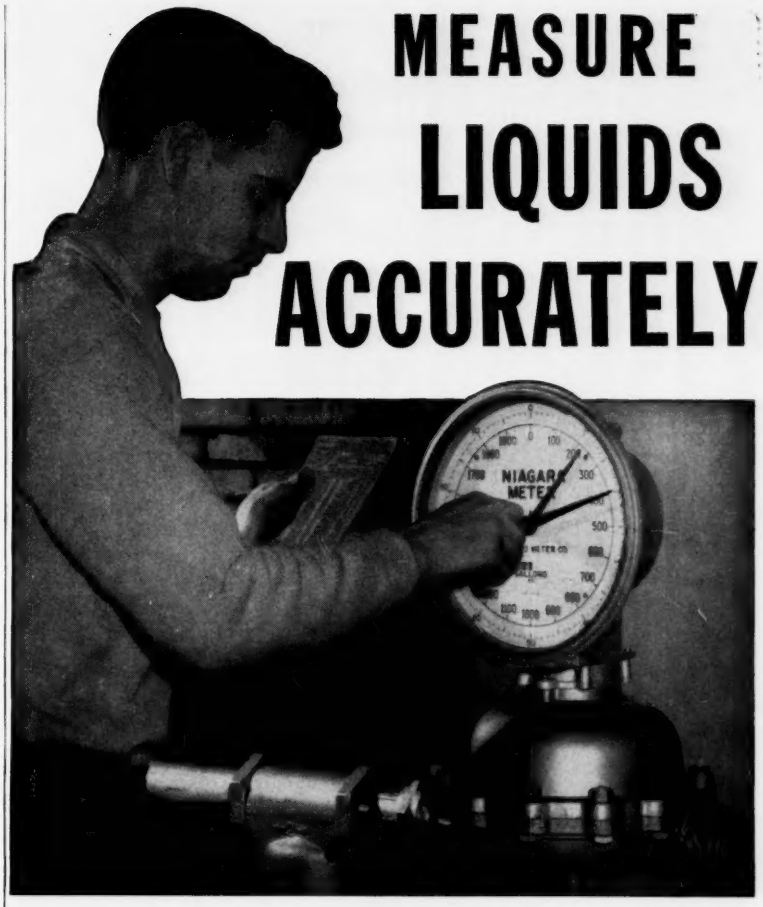

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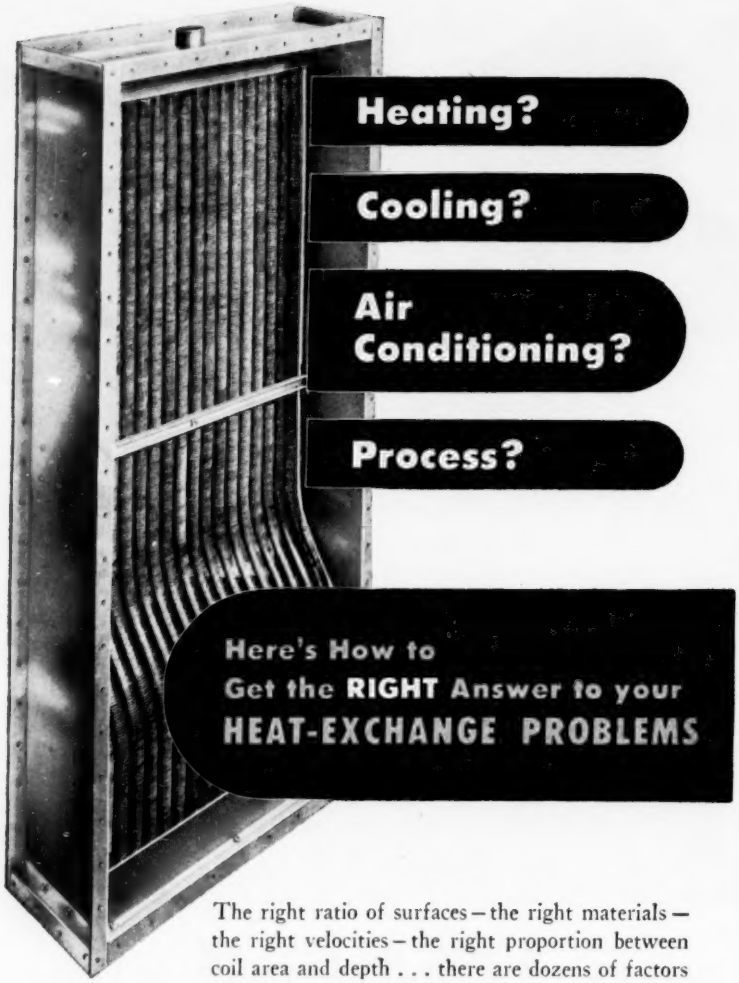

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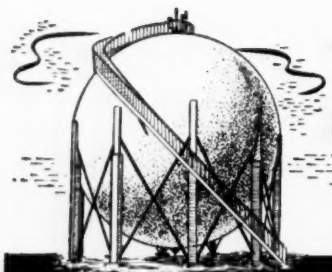

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LITERATURE . . .

Trichloroethylene.....36 p. "Nialik Trichloroethylene for Vapor Degreasing & Other Uses", booklet 44-A, is an expanded edition on a chlorinated solvent of high purity.
152A Hooker Chemical Co.

Urethane Foam.....4 p. bulletin, PAB No. 4-F3 by M. Glickman, Test Engineer, American Bridge Div., U. S. Steel Corp. titled "Urethane Foam in Curtain Wall Construction."
152B Mobay Chemical Co.

Water.....Bulletin No. 16 lists the individual & comprehensive tests that are available. Laboratories offer analyses, research and development.
152C Crippen Laboratories, Inc.

Construction Material

Alloy Steel Plates.....for any job, to any specification. Fabrications Shop turns out partially or full-fabricated steel plate components. Complete information.
67 *The Colorado Fuel & Iron Corp.

Aluminized Steel.....can be used in thinner gages & at higher temperatures than other metals. Complete information about Aluminized Steel Type 1 is now available.
59 *Armco Steel Corp.

Brick Products.....Catalog presents information on the manufacturer's line of chemically resistant brick, floor brick and quarry tile. Specifications.
152D Hanley Co.

Coating.....Zinkote for protecting steel is completely nonflammable, nontoxic. Resists temperatures up to 600 F. Applied by brush, spray or roller.
121 *Amercoat Corp.

Coating.....Duracor combines extreme chemical resistance & high strength with light weight, heat & flame resistance. Visual standards & industry specifications offered.
157 *The Ceilcote Co., Inc.

Coatings, Corrosion Resistant.....Bul. No. 259 covers the advantages of Plasite cold set coatings. Also lists all the bulletins that are available on Plasite Coatings.
152E Wisconsin Protective Coating Co.

Corrosion.....Wall chart provides comparative corrosion resistance of zirconium, titanium, tantalum, Hastelloy C and Stainless 316 to 43 commonly encountered reagents.
152F Damascus Tube Co.

Corrosion Calculator.....Detailed calculator shows preferred materials for 247 different types of corrosive substances. Also lists manufacturer's products.
152G Hoke, Inc.

Corrosion Guide.....lists & describes the more common alloys that resist corrosion. Approximate physical & mechanical properties are given plus application & suitability.
152H The H. M. Harper Co.

Impregnated Wood.....Bulletin describes the properties and availability of Kofural, a chemical-resistant material of construction having a lumber base.
1521 Koppers Co.

* From advertisement, this issue

LITERATURE . . .

Metal Packings.....Bulletin deals with subject of metal packings for pumps, engines and compressors. Describes free-floating, annular solid cup, multigroove types.
153A Garlock Packing

Metal Screen.....Literature describes new line of pierced metal screen and a wedge wire screen having applications in the process industries. Specifications.
153B National Standard Co.

Plastic Lining.....Fluorocarbon Linings are chemically-inert, tough, and withstand heat and cold (—320 F. to +250 F.) Further information in Bulletin AD-152.
137 *United States Gasket Co.

Steel.....Union 20-S is a new source for pipe, tube, strip, sheet, plate, bar, & wire. Complete information contained in Bulletin 20-S. Send for your copy.
51 *Union Steel Corp.

Titanium.....Comprehensive handbook outlines the corrosion-resisting properties of titanium. Also covers design and fabrication characteristics. On request.
153C Titanium Metals Corp.

Zinc Dust.....used as a reducing agent, precipitating agent, purifier, catalyst, polymerizing agent, in rust-resistant paints, bleaches, etc. Experimental half-pint sample.
143 *American Smelting & Refining

Electrical & Mechanical

Casters & Wheels.....with a wide choice of treads suited to all types of floors. Manual describes over 4000 types of casters and wheels that are available.
R160 *Darnell Corp.

Couplings.....An expanded line of Paraflex flexible-cushion couplings ranging from fractional to 190 hp. per 100 rpm. is the topic of a new, illustrated bulletin.
153D Dodge Mfg. Corp.

Motors and Generators....."Electric Motors and Generators . . . A-C and D-C" covers squirrel-cage motors, special-purpose motors, wound-rotor motors and generators.
153E Imperial Electric Co.

Powers Systems.....Descriptive bulletin explains the manufacturer's Inverter-Diverter Continuous AC & DC Power System. This system is for emergency standby power.
153F Electric Products Co.

Pump Motors.....Topic of Bulletin F-1953 is a new line of Holloshaft turbine pump motors for outdoor service. Principles of design are clearly illustrated.
153G U. S. Electrical Motors, Inc.

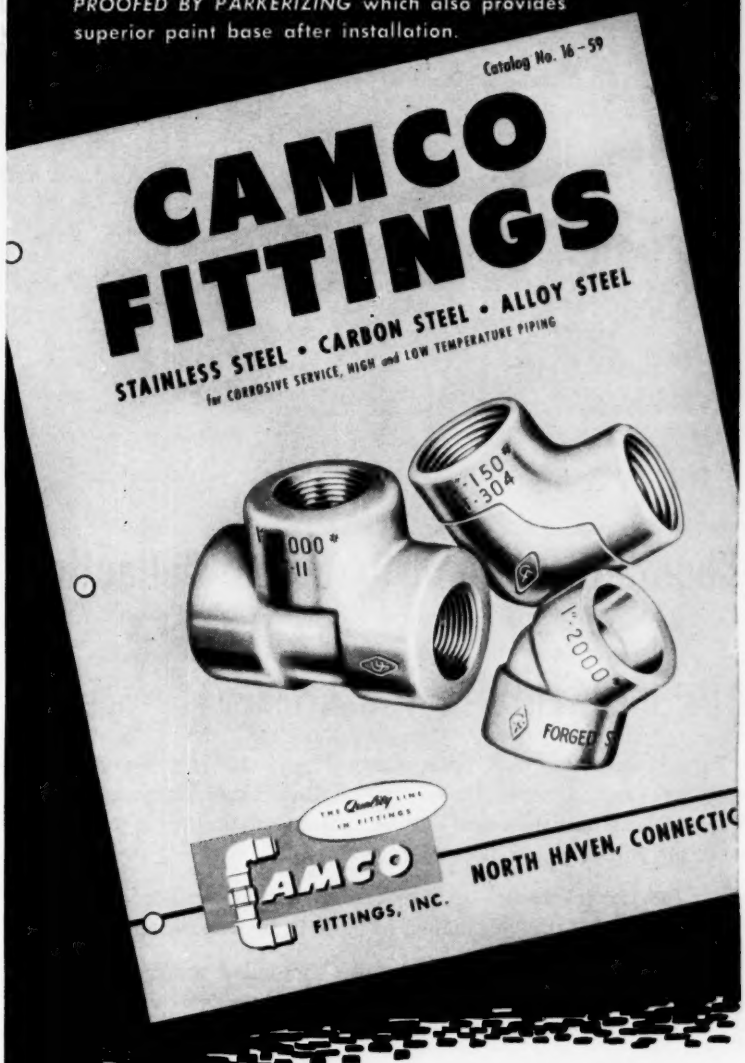
Mechanical Seals.....A new file folder of mechanical seal designs shows some of the many types & applications possible for pumps, mixers, autoclaves, etc.
129 *Borg-Warner

Self-Lubricating Packings.....Catalog presents information on line of self-lubricating packings. Construction, advantages, and applications in pumps and valves.
153H Green, Tweed & Co.

* From advertisement, this issue

now available...

FORGED STEEL screwed and socketweld pipe fittings (2000# thru 6000# rating) with all surfaces *RUST PROOFED BY PARKERIZING* which also provides superior paint base after installation.



A complete line of *STAINLESS STEEL* fittings in all pressure ratings from 150# thru 6000#.

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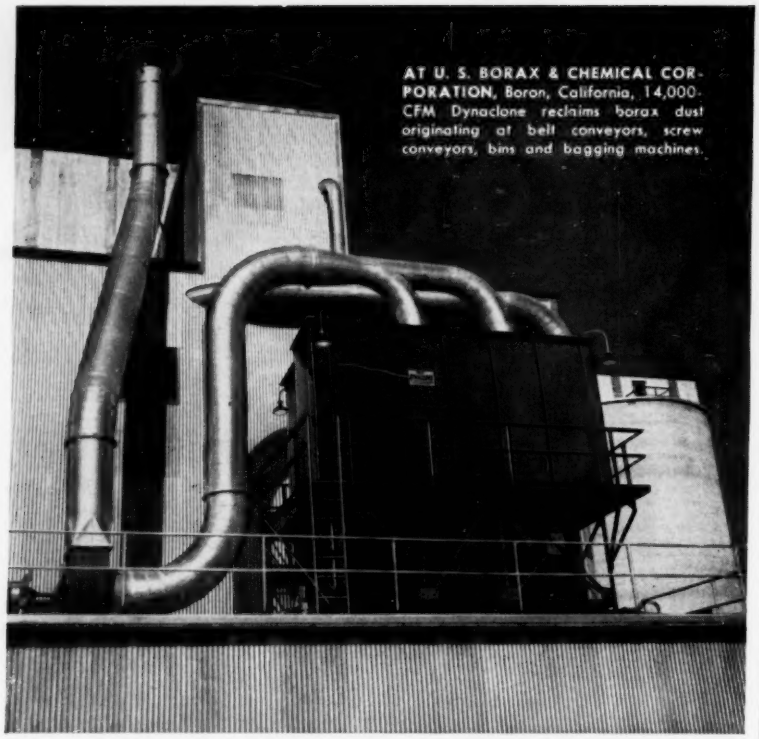

AT U. S. BORAX & CHEMICAL CORPORATION, Boron, California, 14,000-CFM Dynaclone reclaims borax dust originating at belt conveyors, screw conveyors, bins and bagging machines.

Constant Suction! Complete Collection!

SLY DYNACLONE®

The Dust Filter for Continuous Processes

Just turn this dust filter on and forget it. The Dynaclone operates continuously, 24 hours a day. It maintains constant, uniform suction at dust sources, reclaims all the dust to prevent air pollution and damage to plant equipment.

The Dynaclone has *new* "Resist-O-Wear" filter bags (patent pending) that give as much as three times longer bag life . . .

It has a new roller cleaner for simplified automatic self-cleaning. Resilient rubber rolls form a positive dust seal as each row of bags is cleaned by atmospheric air drawn in by the main operating fan.

And it contains more cloth per cubic foot of filter than any other make . . . greater filtering capacity with smaller space requirements.

Learn the many reasons why the Dynaclone represents a new high in dust filter efficiency . . .

Get the complete Dynaclone story . . .

SEE THE DYNACLONE in Space 73, the Chemical Show, New York Coliseum, Nov. 30-Dec. 4

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LITERATURE . . .

Small Switches.....Catalog covers four basic, small switches. Two are subminiature; one is a 2-circuit switch; another is postage-stamp size. Illustrated.
154A Micro Switch

Motor Starter & Circuit Breaker..... now available in 7" & 9" sizes for sizes 1 & 2 starter combinations. Detailed information on the many special features.
18 *Crouse-Hinds

Motors.....Syncrogear Motors offer ⅓ to 50 HP. The color illustrated Brochure No. F-1880 explains the Syncrogear principle. Available on request.
133 *U. S. Electrical Motors, Inc.

Motors, Explosion-Proof.....in sizes up to 600 hp. In a wide range of mechanical modification & electrical characteristics for your requirements. Bul. 800.
105 *Louis Allis Co.

Relay Control Amplifier.....A 4-pg. bulletin gives detailed information concerning principles of operation, performance ratings, & applications. Catalog Sec. 90.
154B Thermo Electric Co., Inc.

Handling & Packaging

Belt Conveyors.....A practical handbook on the use and selection of standardized sectional belt conveyors includes information on applications, operation.
154C Link-Belt Co.

Conveying Guide.....A 12-page conveying guide discusses types of systems, illustrates & diagrams high & low density arrangements & shows equipment. Bul. M-588.
136a *The Day Company

Conveyor Idlers.....Limberoller conveyor idlers are self-cleaning, because they flex constantly as they turn with the belt. Flame & Corrosion resistant. Bul. 353-11.
99 *Joy Manufacturing Co.

Fork Trucks.....New 16-page pictorial review of manufacturer's FT Series fork lift trucks includes information on engineering, construction and operating features.
154D Allis-Chalmers Mfg. Co.

Fork Lift Trucks.....handles 3,000 to 10,000 lb. capacities. Have a low center of gravity for utmost stability . . . automotive-type frame for rigidity, etc. BU-481.
154E Allis-Chalmers

Lift Trucks.....Creative lift truck engineering, new functional styling and improved operating features of a new series of trucks is topic of Bulletin SP-23.
154F Towmotor Corp.

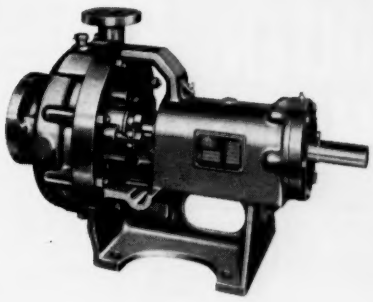
Material Handling.....The new Auto-Bin-Dictator prevents overflowing of bins, clogging of conveyors, choking of elevators, damage to machinery, etc. Bul. AB-19.
TL163 *The Bin-Dictor Co.

Storage Tanks.....Bulletin 574 describes horizontal & vertical storage tanks. Filled with photos of various installations plus decription of auxiliary equipment.
136b *The Day Company

* From advertisement, this issue

Mr. Engineer: Cut Your Pump Inventory—Reduce Costs With These New, Proved Pumps

PEERLESS CHEMICAL PROCESS PUMPS



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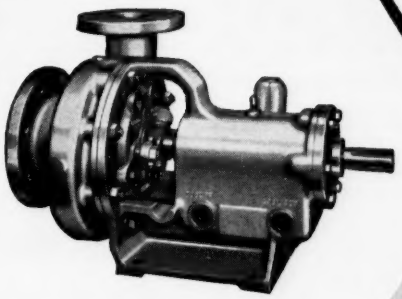

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PEERLESS PUMPS

INTEGRATED DESIGN

SUPERIOR DESIGN + TOP QUALITY CONSTRUCTION
+ MAXIMUM INTERCHANGEABILITY
+ OPTIMUM MATERIAL GROUPS AVAILABLE

= BROADEST HYDRAULIC COVERAGE
WITH MINIMUM CUSTOMER INVENTORY
OF PUMPS AND COMPONENTS

ACCESSIBILITY—Through ease of assembly and disassembly if and when required. **DURABILITY**—Through use of any machinable metal as materials of construction. **SERVICEABILITY**—Through designs that feature maximum ease of maintenance. **INTERCHANGEABILITY**—Through a choice of semi-open or enclosed impellers, oil or grease lubrication, air- or water-cooled back plates and bearing housings. **RELIABILITY**—Through the high performance standards set for these pumps, proving more than ever before, that Peerless Builds Dependable Pumps. **AVAILABILITY**—Shipment from stock of both complete pumps and pump components.

Capacities: UP TO 1000 GPM
Head Range: UP TO 430 FEET
Working Pressure: UP TO 300 PSIG
Temperature Range: UP TO 450° F

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PUMPING MOLTEN CHEMICALS?

write TABER

Whatever your pumping needs .. why not put it up to Taber .. long experienced pump specialists. Vertical pump illustrated, 19,478, for pumping molten chemicals. Horizontal pump, 6043, handles black liquor, caustic, etc., in evaporator service; or transfers fluids under vacuum.

WRITE, ON BUSINESS STATIONERY FOR BULLETIN V-837

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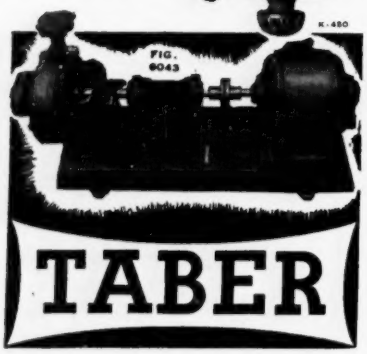


TABER

LITERATURE . . .

Heating & Cooling

Condensers, Vapor.....gives more capacity at a saving of steam & power. Unit capacities up to 15 million BTU. For full information request Bulletin 129R.
TL165 *Niagara Blower Co.

Equipment.....Bul. E-1 shows designs in heat exchanger, oil chillers, crystallizers, steam generators, & ice making & refrigerating machinery for application in industry.
68 *Henry Vogt Machine Co.

Fired Heat Exchangers.....Bulletin 113 describes various types of fired heat exchangers. Gives complete specifications for ratings to 1,900 F., 5,000 psi., 550 lb./sec.
156A Thermal Research & Engineering

Heat Exchanger.....The C-100 can be used as a heater, cooler, condenser or vaporizer for hundreds of process aplications. New illustrated Bul. 302.5K1 offered.
107 *American-Standard

Heat Exchanger Equipment.....The 162-page Condenser Tube Handbook answers problems, questions involving heat exchanger equipment. It is available now.
56 *Bridgeport Brass Co.

Heat Exchangers.....Bulletin B-20 gives details on the design and application of the manufacturer's line of standard heat exchangers. Sizes to about 1,200 sq. ft. of surface.
156B *Struthers Wells

Heater, Steam.....Heat & agitate liquids in tanks, efficiently & economically. Bul. 3A-HC includes application information & data on sizes, dimensions & capacities.
109 *Schutte & Koerting

Insulation.....Brochure lists all types of Carey industrial insulations and insulating cements for use in the process industries. Also selection guide.
156C Philip Carey Mfg. Co.

Plate Heat Exchanger.....All heat transfer surfaces are immediately exposed for manual cleaning with a minimum of trouble. Further information on request.
156D The De Laval Separator Co.

Preheater, Air.....Factual information on Ljungstrom Air Preheater is contained in a reprint of a published magazine article which is available on request.
141 *The Air Preheater Corp.

Thermo-Panel Coils.....Take the place of old-fashioned pipe coils. Complete data and prices on the latest models which assure increased capacity are available.
BL166 *Dean Products, Inc.

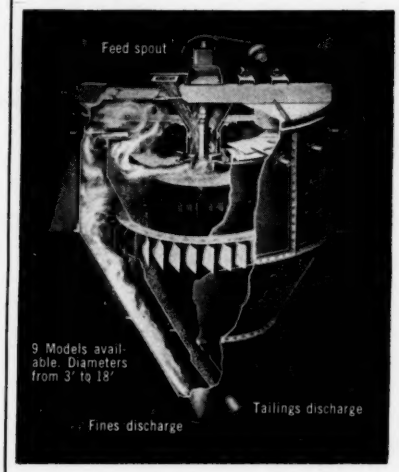
Vaporizers.....Full technical information on vaporizers & the Heat Engineering service that goes with them is now available on your request
31 *Foster Wheeler Corp.

Finned-Tube Exchangers.....A line of Radiafin heat exchangers for aid and gases is the topic of Bulletin 11R. Crimped, spiral-wound fins provide extra surface.
156E Schutte & Koerting Co.

* From advertisement, this issue

Size Requirements Getting Tougher?

Sturtevant Air Separators Increase 40 to 400 Mesh Output as Much as 300%



Closed-circuit air separation is of proved advantage in reduction processes. Result is a better, more uniform product. Grinding mills perform at top efficiency, output frequently increases as much as 300%, power costs drop as much as 50%.

Precise separation of all dry powdered materials. Sturtevants currently classify sulfur, soybeans, phosphate, chocolate, feldspar, sand and aggregates, pigments, limestone fillers, flour, abrasives, plastics, gypsum, ceramics, cement and other products.

Improve screening — Sturtevant Air Separators prevent blinding by removing undesirable tailings *or* fines from screen feed loads.

Works Like Winnowing Done in a Whirlwind

Sturtevant Air Separators do a mechanical job of winnowing. Precise control of whirlwind air currents and centrifugal force results in the desired size being lifted into fines cone, oversize falling into tailings cone.

A 16 ft. Sturtevant, for example, has taken a feed rate of 800 tph, containing only a *small* percentage of desired fines, and delivered 30 tph 90% 200 mesh, recirculating the oversize through the grinding circuit.

Send for Bulletin No. 087.

STURTEVANT
MILL COMPANY
100 Clayton St., Boston, Mass.

Crushers • Grinders • Micron-Grinders • Separators
Blenders • Granulators • Conveyors • Elevators
SEE US AT THE CHEMICAL SHOW—BOOTH 421

Instruments & Controls

Electronic Weight Detector.....true weight of any load can be automatically obtained & recorded without need of a weighman. Complete information on request.
126 *Fairbanks-Morse

Gas Analyzers.....Recording Gas Analyzer continuously analyzes & records as many as six constituents of a gas. Single & Multi-point instruments are available. Llt.
TL166 Cambridge Instrument Co., Inc.

Hydrostatic Instruments.....New pocket-size handbook of hydrostatic instrumentation aids specification, purchase, installation or operation of instruments.
157A Petrometer Corp.

Instrument.....Elec-O-Level provides a continuous indication for level measurement & control of liquids solids, viscous fluids, acids & granular materials. Bul. L-1053.
T175 *Instruments, Inc.

Liquid Meters.....Catalog provides a new and simplified basis for selecting a volumetric meter for any given application. Full specifications. Illustrated.
157B Buffalo Meter Co.

Nuclear Instruments.....Illustrated bulletin covers company's line of nuclear instruments and monitoring systems. Includes scalers, spectrometers, survey units.
157C Victoreen Instrument Co.

Oxygen Analyzer.....Detailed specifications on an oxygen analyzer that withstands tough environments & gives you continuous, dependable answers in Data File P-14-45-08.
123 *Beckman Instruments, Inc.

Pyrometers.....Catalog offers a complete description of the theory of radiation pyrometry as well as construction and operation of Radiomatic pryometers. Photos.
157D Minneapolis-Honeywell

Meters, Displacement.....measure liquids accurately up to 100 gpm. insuring greater uniformity of product. Meters measure volumetrically. Complete information.
151 *Buffalo Meter Co.

Pneumatic Transmitters.....made in pressure & temp. types, each in regular & short span. Operation is on low-pressure air: output range, 3-15psi or 3-27psi. Bul. 361.
12 *Manning, Maxwell & Moore, Inc.

Recorder-Controllers.....The full story on the low-maintenance, accurate pneumatic Consotrol Recorder-Controllers is available. Details in Bulletin 13-18.
8-9 *The Foxboro Co.

Temperature Control.....available in pneumatic, electric or self-contained gas types, in recording, indicating or non-indicating models. Full details offered.
66 *The Partlow Corporation

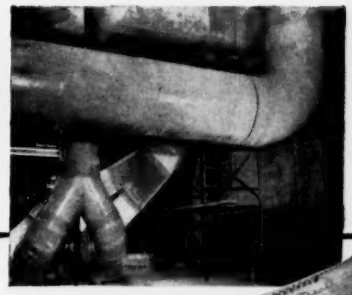
Temperature Regulator.....available in sizes ½" to 1-½". Temperature ranges as low as 15 F. to 50 F.—as high as 240 F. to 350 F. Information in Bulletin 114A.
138 *Manning, Maxwell & Moore, Inc.

* From advertisement, this issue

corrosion resistant **DURACOR** replaces costly metal fabrications

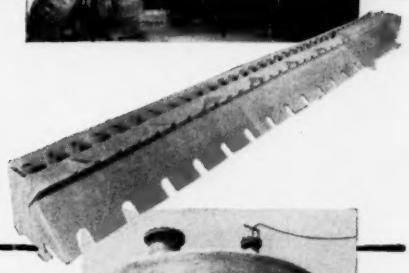
in the **METALWORKING** industry

Ceilcote engineers complete ventilating systems, gas scrubbing towers, hoods, tank covers, ducts, recovery tanks and other customized fabrications.



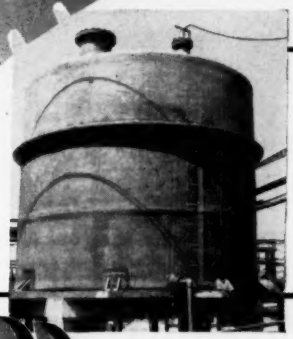
in the **TEXTILE** industry

Complex rayon spin machines, feed pipes, filters, screens, tanks and similar equipment are fabricated from Duracor.



in the **PETROLEUM** industry

Acid storage tanks, tank trailers, exhaust systems, pressure pipes and other Duracor products are rendering outstanding service.



in the **CHEMICAL** industry

Duracor is used extensively for special processing equipment, processing tanks, laboratory sinks, brine tanks, acid storage tanks, covers and ventilating systems.

PHYSICAL PROPERTIES

Tensile Strength p.s.i.: 11,000-15,000
Flexural Strength p.s.i.: 20,000-30,000
Tensile Modulus of Elasticity p.s.i.: 1.2—1.4 x 10^6
Flexural Modulus of Elasticity p.s.i.: 0.78—1.6 x 10^6
Impact Izod, Notched ft.-lbs./in.: 30—40
Specific Gravity: 1.4
Coefficient of Linear Expansion: 9.5 x 10^{-6} in./in./°F.
Standard Color: Light Green/Gray
Maximum Temperature (Exposure): To 500°F.

Save up to 40% over costly metal structures with Duracor processing equipment and ventilating systems! A product of Ceilcote's 33 years of corrosionproofing experience, Duracor combines extreme chemical resistance and high strength with light weight, heat and flame resistance. WRITE TODAY FOR VISUAL STANDARDS AND INDUSTRY SPECIFICATIONS!

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4836 Ridge Road • Cleveland 9, Ohio

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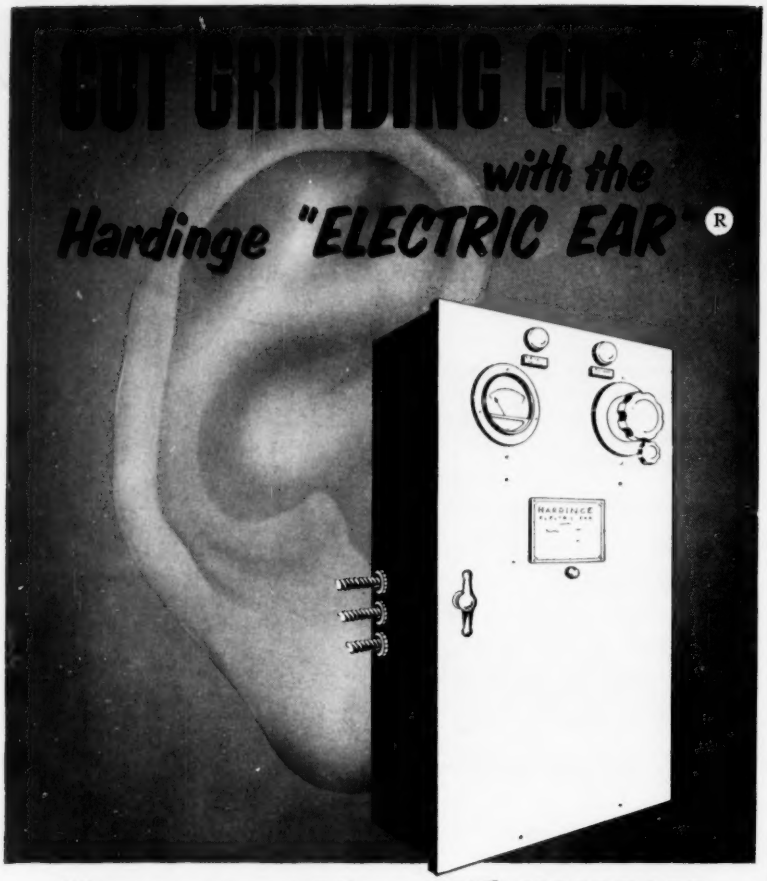

Users report 10 to 15% INCREASE in their GRINDING MILL CAPACITY

In a recent survey of Hardinge "Electric Ear" users, many of them reported 10% to 15% increased grinding mill capacity after installing an "Electric Ear." This unit controls the mill feed, based upon grinding sound level, to produce optimum grinding conditions.

Here are a few typical statements from satisfied customers:

"This unit is doing a remarkable job. It reduces steel and liner consumption. We estimate a savings, with our two units, of $6000 per year on grinding balls and liners. Capacity gained 10%."

"Approximately 25% gain in capacity."

"Helps prevent plug-ups."

"Maintains uniform mill load. Estimated gain in capacity 10%."

"We feel this unit is essential to our operation from a proper quality control standpoint. We would not be able to keep up our present rate of accelerated production and quality without it."

"'Electric Ear' is helpful when inexperienced grinders are learning to operate the mills."

"Eliminates human element in mill feed level."

"Saving per year—$10,000.00."

"Principal reason for 'Electric Ear' use is that it aids the operator, and the mill can be operated from a remote panel."

Write for Hardinge Catalog No. 42A-11.

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LITERATURE . . .

Thermocouples.....Revised Catalog EN-S2 offers complete information on the manufacturer's full line of thermocouples and thermocouple components and accessories.
157E Leeds & Northrup Co.

Viscosity Measurement & Control..... Data pertaining to viscosity measment and control problems is available now on request. Technical articles & references.
B176 *Broofield Engineering Lab.

Pipe, Fitting, Valves

Fittings.....A complete line of stainless fittings in all pressure ratings from 150# thru 6000#. New catalog covering the complete line is now available.
153 *Camco Fittings, Inc.

Heat Exchanger Tube.....Condensed 8-page brochure outlines the principle features, technical information and composition for manufacturer's line of tubing.
158A Scovill Mfg. Co.

High Vacuum Equipment.....Valves, baffles, traps and a combination valve and baffle for high-vacuum operations are described in new bulletin. Selection guides.
158B Consolidated Electrodynamics

Hose and Couplings.....Hose for fuel oils, gases, solvents and marine use, and couplings for the same are described in new bulletin. Specification tables. Illustrated.
158C Metal Hose & Tubing Co.

Pipe & Fittings.....PVC for industrial piping withstands shock, impact, vibration & twisting; can be used at higher pressures than other similar materials. Information.
164b *Mueller Brass Co.

Pipe, Fittings, Valves.....Catalog 356 contains details including charts, diagrams & illustrations on jacketed piping, fittings, plug valves, joints, etc.
158D Parks-Cramer Co.

Pipe, Plastic.....New 36-pg. Technical Handbook on PVC pipe is filled with information including flow charts & a corrosion resistance chart covering more than 160 acids.
7 *Kraloy Plastic Pipe Co., Inc.

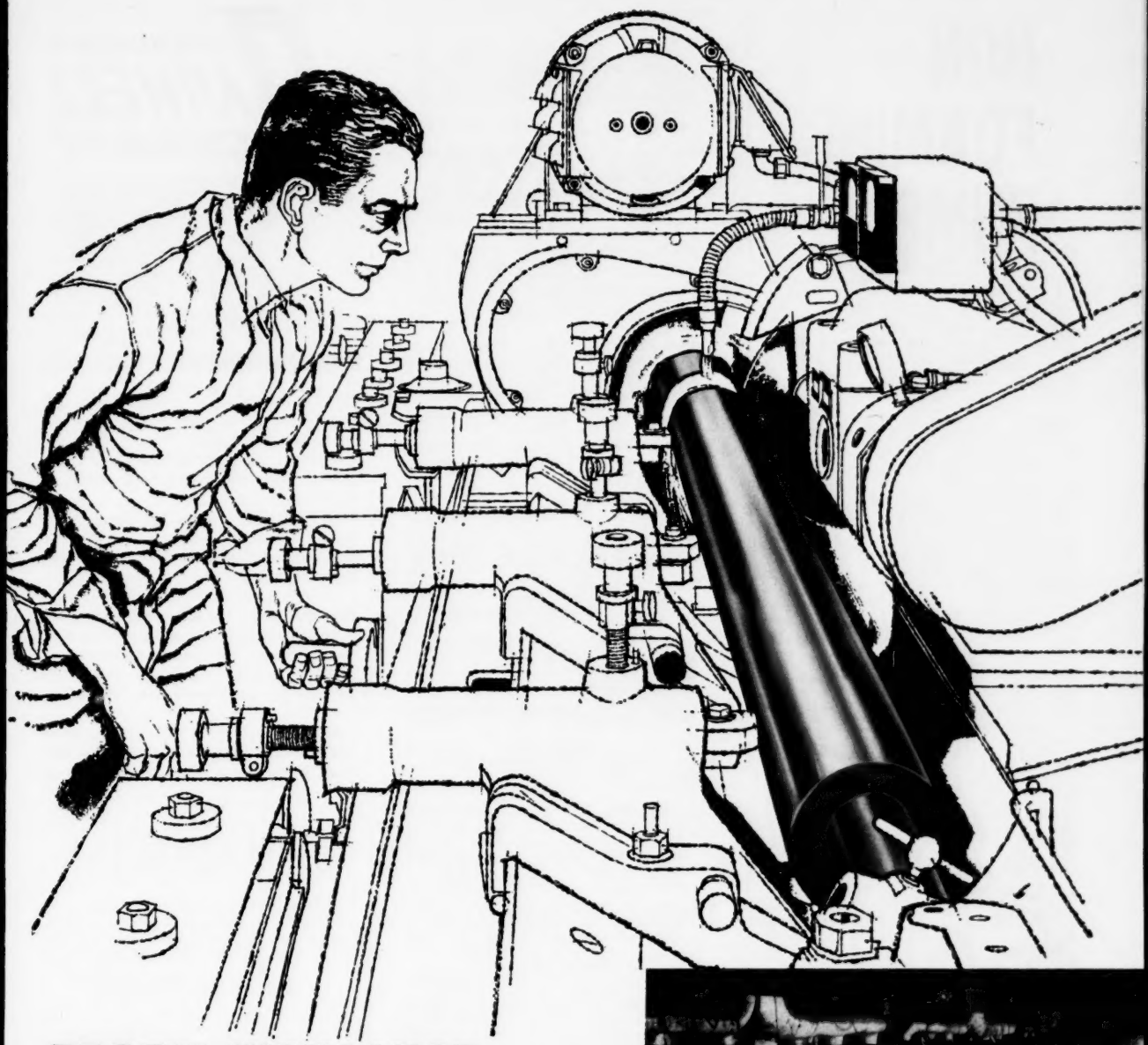
Tube & Fittings.....Streamline copper tube & solder-type fittings make a tight, sanitary system with clean, unobstructed joints that withstand vibrations. Details.
164a *Mueller Brass Co.

Tubes.....A complete range of stainless grades to meet any set of service conditions . . . fully annealed tubes for maximum resistance to corrosion. Bulletin TB-329.
64 *The Babcock & Wilcox Co.

Valve.....The new drain or sampling valve is completely self-draining & withstands severe conditions. Data unit and complete details available.
R165 *Jerguson Gage & Valve Co.

Valve Actuator.....The Robotarm is a cylinder-type valve actuator designed for all types of 90 degree rotating mechanisms. Descriptive bulletin is offered.
124 *Bettis Corp.

* From advertisement, this issue



PROFIT INSURANCE with J&L Stainless Steel Bars

Your machining costs on stainless steel bars are part of your investment for profit. Add your costs for tooling, handling and polishing, and you multiply your investment, often many times over.

Scrapping a single bar wipes out that investment—and with it most of your profit on a large volume of finished goods.

Every step taken to reduce rejects helps insure profits! The biggest step you can take in that direction is to specify J&L **Consistent** Quality on all orders for stainless steel.

J&L leads the industry in melt shop standards for stainless steel —the point where quality starts, **and your profit insurance begins.**

Careful attention to every production detail is the key to J&L quality

J&L

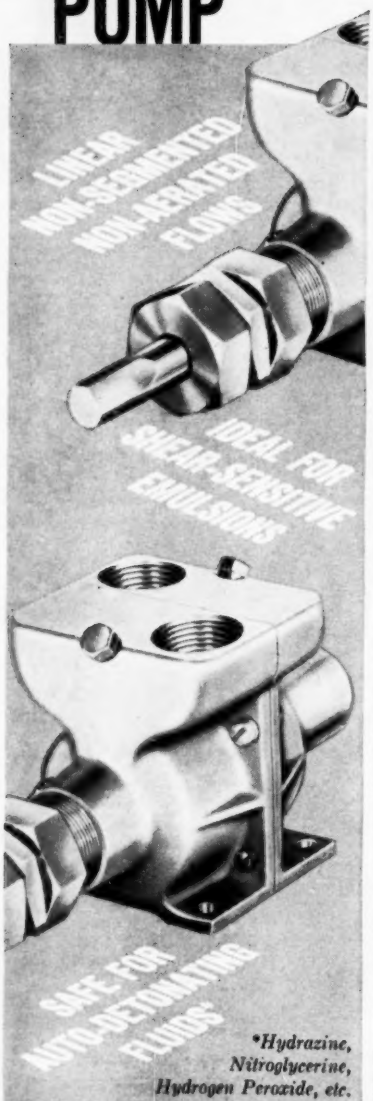
STAINLESS

SHEET • STRIP • BAR • WIRE

Plants and Service Centers:

Los Angeles • Kenilworth (N. J.) • Youngstown • Louisville (Ohio) • Indianapolis • Detroit

NON-FOAMING PUMP



Hydrazine, Nitroglycerine, Hydrogen Peroxide, etc.

Write for Literature on ALL-CHEM® PUMP

ECO ENGINEERING COMPANY
12 New York Ave., Newark, N. J.

ECO
the big name in small pumps for the process industries

LITERATURE . . .

Valve, Ball.....Illustrated booklet contains a general summary of design features & advantages, industrial applications, maintenance, material, and sizes.
158E Jamesbury Corp.

Valves.....“Valve Performance Facts” a booklet of 32 case histories on Crane installations, gives you many ideas for valve savings. It is available on request.
53 *Crane Company

Valves.....made of non-porous, cast red brass & all working parts are precision machined for perfect alignment of seating surfaces. Complete information.
164c *Mueller Brass Co.

Valves, Control.....New 20-pg publication lists valve bodies & actuators and the accessory line available for control valves. Valve sizing data included in Bul. 150.
160A DeZurik Corporation

Valves, Diaphragm.....Dependable performance & long service life for vacuums down to 0.1 micron . . . with leak rates of less than 0.1 micron cubic ft./hr. Facts.
140 *Grinnell Company

Valves, Solenoid.....in conduit type and grommet type. Port sizes ⅛” and ¼” NPT. Ten orifice sizes 3/64” through ¼”. Wide range of voltages. New bulletin.
T176 *Marsh Instrument Co.

Valves, Solenoil.....are covered in an 8-page article entitled, “How To Specify Solenoid Valves.” It includes diagrams and charts on the different series.
160B Valcor Engineering Corp.

Process Equipment

Air Separators.....There are 9 models available with diameters from 3' to 18'. Precise separation of all dry powered materials. Further details in Bul. No. 087.
R156 *Sturtevant Mill Co.

Blending.....“A Handbook on Mulling” explains the mulling principle of blending dry, semiliquid and dry, solid materials in the Simpson Mix-Muller. Charts and photos.
160C National Engineering Co.

Centrifugal.....Continuous Solid Bowl type for low cost solid-liquid separations involving moderate volumes, or limited space or extra powerful searating forces. Details.
2 *Bird Machine Co.

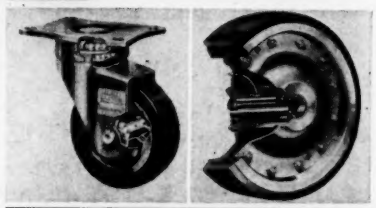
Dehumidifier.....Apparatus uses liquid absorbent for drying air to control its properties for industrial processing and product drying at low temperatures. Bulletin.
160D Niagara Blower Co.

Demineralizers.....are available in mono-column, dual-column & multi-column types . . . in flow rates from 10 to 10,000 GPH. Fifty standard models to choose from. Catalog.
R163 *Penfield Mfg. Co., Inc.

Dryers....Drying Systems with proven efficiency in processing chemicals, foods, pharmaceuticals, tobacco, synthetic rubber, textile fibers, veneers, etc. Bul. #443.
55 *Proctor & Schwartz, Inc.

*From advertisement, this issue

DEPENDABLE DARNELL
CASTERS AND WHEELS



RUBBER TREADS . . . a wide choice of treads suited to all types of floors, including Darnelloprene oil, water and chemical-resistant treads, make Darnell Casters and Wheels highly adapted to rough usage.

RUST-PROOFED . . . by zinc plating, Darnell Casters give longer, care-free life wherever water, steam and corroding chemicals are freely used.

LUBRICATION . . . all swivel and wheel bearings are factory packed with a high quality grease that "stands up" under attack by heat and water. Zerk fittings are provided for quick grease-gun lubrication.

STRING GUARDS . . . Even though string and ravelings may wind around the hub, these string guards insure easy rolling at all times.

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36 NORTH CLINTON STREET CHICAGO 6, ILLINOIS

A filter man's thinking about missiles: How vulnerable is fuel purity control?

Today's missiles have prodigious appetites, exotic tastes . . . and delicate innards. The possible consequences of improper diet are alarming. The usual ration of liquid fuels — ultra-cold, explosively volatile — is tough to handle. But the fact is: fuel purity control has proved to be one of missilery's least vulnerable functions. Why? Largely because the humble filter has grown in stature lately.

We know. We make them.

We know it's no accident that filters are available to separate any particle larger than 10 microns from a torrent of corrosive 'LOX' —at –267°F. It's no accident that Purolator can offer industry a filter for liquid helium — to operate at –420°F and 10,000 psi — structurally rugged, compact, easy-to-clean. These are the fruits of years of research into extreme low temperature filtration. We anticipated defense and industrial needs...shaped yesterday's bold concepts into today's practical Purolator equipment. What kind of filters are these? No one kind, of course; they must be tailored to specific applications. But we're working with such media as

(1) frameless metal edge elements — exceedingly strong, unitized structures which we can make out of inconel, monel, platinum, tantalum, many stainless steels, etc. Such media can be operated through tremendous ranges — in some cases from –420°F to 1200°F...or where the temperature change is on the order of 300°/second. Built-in venturi action permits them to handle terrific volumes of fluids with extremely low differential pressures.

(2) fused, porous metal media — with remarkably uniform pore sizes ranging upward from a fraction of a micron.

(3) fibrous metallic media . . . exotic plastic materials of all kinds . . . combinations of these and the above.

We can't begin to tell you — in this column — about the full scope of Purolator's activity in liquid gas applications, or other areas that may interest you more. But our brochure called "New Roles for Filtration" makes good reading. And our "Filter Media Selection Chart"—giving corrosion and temperature factors for all known media — is a valuable reference to have on hand. Write us for either or both. They're yours for free.

Jules P. Kovacs

Jules P. Kovacs, V. P.

Filtration For Every Known Fluid

PUROLATOR

PRODUCTS, INC.

Rahway, New Jersey and Toronto, Ontario, Canada

LITERATURE . . .

Drying Equipment.....New catalog No. 201 contains detailed descriptions of the complete line of Drying Equipment. It is available on request.
35 *J. P. Devine Mfg. Co.

Dust Collecting.....Detailed information on how Spiralectrodes contribute to high efficiency of SF Precipitators is described in a new booklet.
127 *Buell Engineering Co.

Dust Collection.....New data and information on dust-collector accessories is given by literature from manufacturer. Accessories for cyclone and cabinet separators.
161A Torit Mfg. Co.

Dust Filter.....The Dynaclone has new "Resist-O-Wear" filter bags that gives as much as three times longer bag life. A 36-page Catalog 104 is offered.
154 *The W. W. Sly Mfg. Co.

Ejectors.....Flier describes its Series M general utility ejectors for low-cost creation of vacuums, increase of pressure, or mixing of gases. Charts and tables.
161B Ingersoll-Rand

Evaporators.....Bulletin E-100 contains complete information on evaporators. Other equipment for the food, chemical, & petroleum industries available.
49 *Swenson Evaporator Co.

Filter Elements.....Bulletin describes seven basic filter element materials and various series of filter assemblies and replacement elements. Illustrated.
161C Bendix Filter Div.

Filtration.....A complete line of filter types: positive self-cleaning edge-type, automatic self-cleaning wire wound, disposable depth cartridge, porous metal, screen mesh.
45 *The Cuno Engineering Corp.

Filtration.....Brochure "New Roles for Filtration" and the "Filter Media Selection Chart" giving corrosion & temperature factors for all known media are offered.
L161 *Purolator Products, Inc.

Filter Presses.....can be made with new glass reinforced Polyester plates & frames. Catalog includes details of Plate-Shifters, Closing Devices & other accessories.
149 *D. R. Sperry & Co.

Filters.....Process Filters makes available pilot plant test filters. Data folders "Batch Recovery", "High Solids Removal", "Polish Filter" are offered.
65 *Bowser, Inc., Process Filters

Fluid Processing Equipment.....New "Fluidics" bulletin of interest to all companies handling or processing liquids or gases is now available. Illustrated.
161D Pfaudler Permutit Inc.

Generator, Nitrogen.....Bulletin No. 197 describes the generator & how it works. Also covers the advantages of the process and a table of all the sizes.
161E Lindberg Engineering Co.

Grinding Mill.....The "Electric Ear" unit controls the mill feed, based upon grinding sound level, to produce optimum grinding conditions. Catalog No. 42A-40 offered.
158 *Hardinge Company, Inc.

* From advertisement, this issue

INSTRUMENTATION IN SCIENTIFIC RESEARCH

Electrical Input Transducers

Just Published: A complete collection of basic methods and systems used as input transducers in electrical instrumentation. Virtually all transducers for mechanical thermal, magnetic and electrical quantities, and optical and nuclear radiation are covered. For each transducer the book describes physical mechanisms, relationships between input and output, applications and limitations, errors, response to environmental influences, and other aspects. **By K. S. Lion, Mass. Inst. of Tech. 310 pp., 297 illus., $9.50**

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- New, fully-enclosed, weather-proofed mechanism—available in sizes through 72" dia. for light, medium, heavy and extra heavy duty in tanks to 150' dia.
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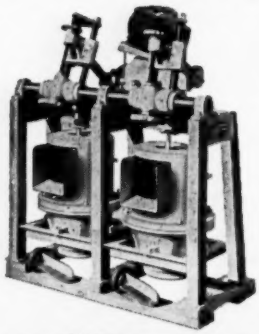
- Spiral rakes move settled solids to center discharge port in only one revolution. Other types of rakes available to suit operation. Rubber covered or stainless steel shaft and rakes for corrosive applications.

Write for Bulletin No. T5-B6.



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...for handling and metering thickened solids.

Ability to adjust stroke while pump is operating makes pump particularly useful. Low head design ...anti-friction bearing construction. Large, specially-shaped nylon reinforced rubber diaphragm gives long life. Rubber covered and stainless steel construction available. Sizes 1" to 10", simplex and duplex in capacities to 1000 g.p.m.

Write for Bulletin No. P8-B12.

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STEEL HEAD MILLS | SRL PUMPS | AGITATORS | SCREENS

LITERATURE . . .

Grinding Mills.....for wet or dry grinding. Available in 29 different diameter sizes, from 12" to 12'6" inside diameter. Capacities up to 6650 tons per 24 hr.
134 *The Mine & Smelter Supply Co.

Hermetic Centrifuges.....can handle corrosion problems in epoxy resin processing. Engineering & full scale pilot plant at your service. Complete information offered.
162A The De Laval Seperator Co.

Impact Mill.....for finer & more intimate dispersion of solids. Literature on Impact Milling, Particle Size Reduction & the new line of Vibrating Screens is offered.
B174 *Entoleter Div., Safety Industries

Mixer.....New Model RL Hi-Shear offers finer, faster blending, dispersing & homogenizing. Features controllable flow pattern. All parts stainless steel. Information.
128 *Gabb Special Products, Inc.

Mixer.....Bulletin provides information on a continuous mixer that combines liquids, liquids and gases, and liquids and solids. Installs in pipeline. Construction details.
162B Nettco Corp.

Mill, Colloid.....for emulsifying, homogenizing, dispersing, disintegrating. Brochure covers advantages, improvements, operation and the applications.
162C Chemicolloid Laboratories, Inc.

Mills, Impact.....Bulletin tells most efficient method of achieving particle size reduction by centrifugal force. Available in all sizes for any requirement.
162D Safety Industries, Entoleter Div.

Mixers, Centrifugal.....New principle of high speed mixing producing intimate dispersion is covered in bulletin. Compact unit adaptable to continuous or batch system.
162E Safety Industries, Entoleter Div.

Oil Reclaimer.....purifies vacuum pump oil by continuous recirculation, either on a full-flow or bypass basis or intermittently on a batch basis. Bul. R-160.
132 *The Hilliard Corp.

Process Equipment.....New publication describes an intensive line of equipment for the processing of chemicals, food products and for recovery of byproducts.
162F Blaw-Knox Co.

Process Equipment.....The AC-VO-3 "Nozzle-Matic" offers processing efficiency, higher capacities & elimination of shut-down for manual cleaning of centrifuge bowls.
162G The De Laval Separator Co.

Process Equipment.....including drum flakers and dryers, rotary and conical vacuum dryers, vacuum shelf dryers, granulators, Tornado mills, etc. Full information.
177 *F. J. Stokes Corp.

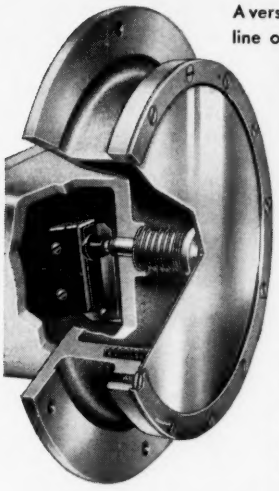
Process Mixers.....Bulletin 581 covers the complete line of impellers including the design & performance which are major factors in the success of process mixers.
144 *Nettco Corp.

Processing Equipment.....Modern techniques in metallurgy, welding, or testing for producing processing equipment. The handy index to the ASME Code is available.
13 *Downington Iron Works, Inc.

* From advertisement, this issue

NEW
AUTO-BIN-DICATOR*

AUTOMATIC BIN LEVEL INDICATOR



A versatile addition to the Bin-Dicator line of bulk material level controls.

NEW corrosion-resistant construction

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NEW super-sensitive operation

Explosion-proof and general purpose models listed by Underwriters' Laboratories, Inc.

Prevents overflowing of bins, clogging of conveyors, choking of elevators, damage to machinery; cuts operating costs. Provides simple, reliable, positive control at low cost.

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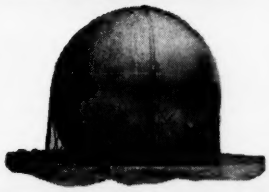

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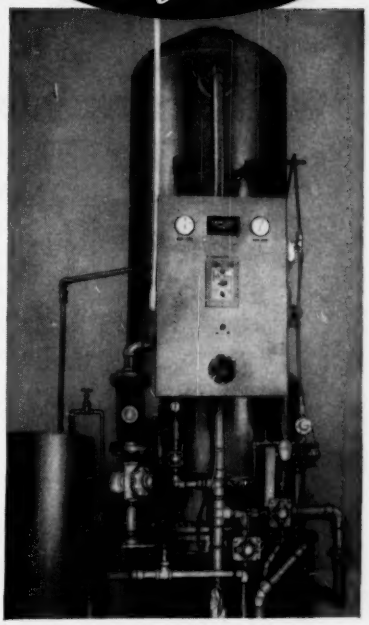

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- **Shipped Completely "Packaged"** — each unit is ready to operate when you receive it.

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**Penfield pioneered "packaged" demineralizers for American industry — and remains today the only manufacturer exclusively making demineralizing equipment.*

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Streamline Copper Tube and Solder-Type Fittings make a tight, sanitary system with clean, unobstructed joints that withstand jars and vibrations. Streamline tube and fittings are lightweight, (longer lengths can be conveniently handled, eliminating many fittings); resist corrosive acids, clogging, will not rust. Products available include K, L, M and DWV copper tube as well as both cast and wrought solder-type fittings in a complete range of sizes.

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Write today for complete information on Mueller Brass Co. products for any industrial piping system.

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MUELLER BRASS CO.

PORT HURON 51, MICHIGAN

LITERATURE . . .

Reactors.....Bulletin describes Pfaudler's "E" Series reactors, and highlights recent major improvements in construction. Glassed-steel units to 2,000 gal.
164A The Pfaudler Co.

Screens, Vibrating.....Important new design, compact, high capacities, low power requirements for long life. Available in all sizes to meet requirements. Bulletin.
164B Safety Industries, Entoleter Div.

Spiral Rake Thickeners.....for all water & waste treatment, countercurrent washing & thickening & clarification operations. Details in Bulletin No. T5-B6.
162a *Denver Equipment Co.

Steam Heated Still.....with Condensate Feedback Purifier completely eliminates the need of cleaning a Still & also produces distilled water of highest purity. Bul. 145A.
178a *Barnstead Still & Sterilizer Co.

Ultrasonic Homogenizers.....New illustrated bulletin describes techniques and applications possible with manufacturer's line of ultrasonic homogenizers.
164C Sonic Engineering Corp.

Pumps, Fans, Compressors

Compressors.....Booklet entitled "Compressed Air Fundamentals" aids selection of small packaged air compressors. Tabular and chart data on engineering with air.
164D Ingersoll-Rand

Compressors, Dynamic.....supplied in sizes from 15 to 15,000, & designed for any class of service from furnishing plant air to compressing hot process gases. Bul. 348-11.
101 *Joy Manufacturing Co.

Compressors, Reciprocating.....are available in a wide range of sizes for both oil-free and plant air service. Complete information contanied in Bul. 349-11.
103 *Joy Manufacturing Co.

Fluids Handling....."Buyers' Guide to Equipment and Services for Handling and Processing Liquids and Gases" covers complete line of manufacturer's products.
164E Permutit Co.

Process Pumps.....Bulletin covers wide line of pumps designed to handle difficult pumping problems. Horizontal or vertical, propeller and centrifugal. Specifications.
164F Lawrence Pumps, Inc.

Pump.....Non-Foaming pumps are safe for auto-detonating fluids such as Hydrazinc, Nitroglycerine, Hydrogen Peroxide, etc. Literature on All-Chem Pump.
L160 *ECO Engineering Co.

Pump.....The type "KC" is designed to live with corrosive liquids. Horizontal & vertical shaft pumps for handling abrasive mixtures also available. Pump Selector offered.
BL165 *Nagle Pumps, Inc.

Pumps.....Series H Durcopumps are available in twelve standard corrosion resisting alloys with capacities from ½ to 3500 gpm, and heads to 345 ft.
119 *The Duriron Co., Inc.

* From advertisement, this issue

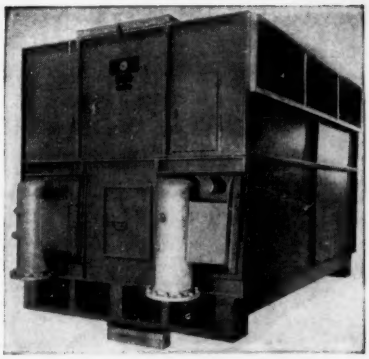
REDUCE OPERATING COST of VACUUM SYSTEMS with this "AERO" (air-cooled) VAPOR CONDENSER

With free air the cooling medium, you use the least water, evaporated in the air stream. You save the cost and pumping of large volumes of condensing water.

Air-vapor subcooling reduces mixture evacuated from the system, saving in the operation of steam ejector or vacuum pump.

This air-cooled condenser gives you more capacity than other types at a substantial saving of steam and power. Water supply, scaling treatment and disposal problems are eliminated.

You get pure condensate, an improved product; often profit by recovery of residues now wasted. There can be no contamination of your product at any time; it never touches raw water. Condensing, of water, of solvents or of your product, is simplified; you have one, compact, easily maintained unit replacing both cooling tower and barometric or surface type condenser.



Niagara Aero Vapor Condenser Panel Casing construction gives access to all parts, saves first costs in shipping and installation.

Maintenance expense is low. Niagara Aero Vapor Condenser Panel Casing construction gives access to all parts, saves first costs in shipping and installation. Summer-winter dampers and Balanced Wet Bulb Control provide precise, year 'round adjustment of capacity to load.

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Write for full information. Ask for Bulletin 129R

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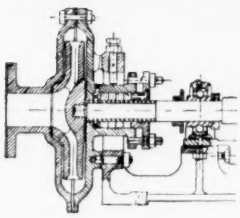
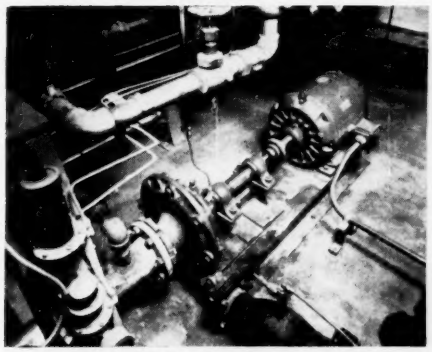
Niagara District Engineers in Principal Cities of U. S. and Canada

BARGAIN HANDLING OF CORROSIVES





with NAGLE "KC" PUMP

The Nagle type "KC" pump is designed to live with corrosive liquids. Impeller and casing are available in metal or alloy best suited to resist the ravages of the particular corrosive being handled. Patented arbor bolt arrangement provides radial adjustment and assures concentricity of shaft in stuffing box. Simple slippage seal adjustment, in sturdy bearing stand. Bearings easily lubricated. Motor can be direct coupled or mounted overhead.

Chemical plants have found the Nagle "KC" pump a real bargain when it comes to handling corrosives. It's a pump you don't have to replace. Pump shown is performing splendidly for a Michigan processing plant. Nagle also builds horizontal and vertical shaft pumps for handling abrasive mixtures or hot solutions such as molten salt or sulphur. Write for Nagle Pump Selector. NAGLE PUMPS, INC., 1235 Center Ave., Chicago Heights, Ill.

Tough jobs call for

Nagle PUMPS

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Completely self-draining valve features freeze-proof outside screw and yoke bolted bonnet; perfect alignment

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New OS&Y Construction: Built for corrosive conditions where inside threads cannot be tolerated. Simplified Outside Screw and Yoke Bolted Bonnet . . . forged yoke supports stem away from valve body; separate forged gland-follower bears directly on packing, entirely independent of yoke.

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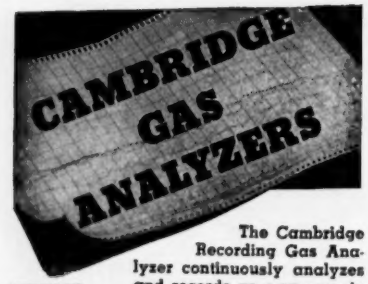

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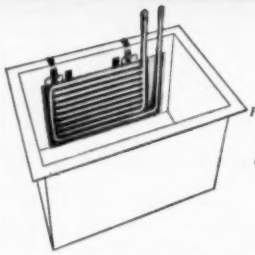

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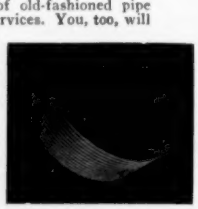

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LITERATURE . . .

Pumps.....Type DM with capacities up to 1000 GPM, head range up to 430 feet, working pressure up to 300 PSIG, & temperature range up to 450 F. Bulletin No. B-1608.
155 *Food Mach. & Chem. Corp.

Pumps.....A line of pumps capable of handling non-abrasive liquids in quantities up to 70,000 gpm. is thoroughly described in a new bulletin. Heads to 400 ft.
166A Peerless Pump Div.

Pumps.....Bulletin V-837 covers vertical pumps for pumping molten chemicals and horizontal pumps for handling black liquor, caustic, etc., in evaporator service.
L156 *Taber Pump Co.

Pumps, Acid.....Pumping parts are available in a variety of metal alloys, as well as plastic, to cover a wide range of corrosive applications. Details.
179 *A. R. Wilfley & Sons, Inc.

Pumps, Diaphragm.....for handling & metering thickened solids. Sizes 1" to 10", simplex & duplex in capacities to 1000 g.p.m. Details in Bulletin No. P8-B12.
162b *Denver Equipment Co.

Pumps, Vertical.....with no submerged bearings for pumping abrasive corrosive slurries. Bul. 203-7 for complete summary of acid & chemical pump data.
130 *Lawrence Pumps, Inc.

Services & Miscellaneous

Cryogenics Application Laboratory..... Research facilities are available for consultation on industrial problems involving low temp. application. Illustrated brochures.
25 *North American Philips Co.

Fume Hoods.....Catalog illustrates and describes a complete line of fume hoods. Includes elevation, duct location and roughing-in drawings. Also blower data, face velocity.
166B Kewaunee Mfg. Co.

Safety Manual.....A practical working guide to safe handling and application of flammable liquids in the process industries is available on request.
166C Protectoseal Co.

Testing Service.....Bulletin 5902 describes the company's Materials Evaluation Div.'s facilities and services for analysis, development, research and inspection.
166D U. S. Testing Co.

Radiation Safeguards.....4 p. "Advanced Film Badge Dosimetry" describes company's film badge service for firms whose personnel may be harmed by ionizing radiation.
166E Controls for Radiation, Inc.

Radiation Safeguards.....8 p. "Bio-Assays for Hazard Control" describes program company offers to continuously assess hazards to personnel in radioisotope operations.
166F Controls for Radiation, Inc.

Water Conditioning.....2 p. "The Care and Operation of Zeolite Softeners" covers bacterial fouling, how exchange materials should be handled for maximum efficiency.
166G Betz Laboratories, Inc.

* From advertisement, this issue

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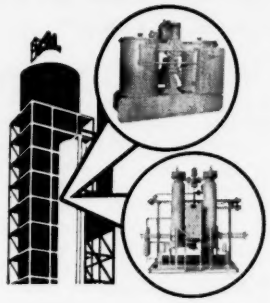

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▶ **Coverage** — National Equipment and facilities—used, resale and rental—for the process industries. For sale, wanted, for rent.

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▶ **Closing date**—November 30th issue closes November 6th. Send all new ads to Chemical Engineering, Classified Adv. Division, P. O. Box 12, New York 36, N. Y.

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4 Mikro's-Bantam, #1SI, #2SI, #4, with motors
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Colloid Mills 1½ HP. & up.
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Sturtev. 1 ton Drum Blender 10 HP.
Blystone 3000# horiz. spiral mixer.
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New 14" x 30" Rubber & Plastic Mills.
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Partial Listings. Write for Bulletins.

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Oliver 5'3"x3' Stainless Precoat Filters
Nooter 750 gal. Steel Reactor 300 PSI
Link Belt 502-16 Roto-Louvre Dryer
Vulcan 9'x100' Rotary Kiln
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Dryers: Link-Belt Monotube of monel.
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Kettles: St. Steel, with and without ag.
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Colloid, 3, 5, 20, 25 hp.
Cog stain. steel, 10 hp.
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Dry Powder, various sizes.
Baker-Perkins size 17, 30 hp.
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1—200 cu ft or 6000# double spiral steel ribbon blender.

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1—Link-Belt #310-20 roto-louvre dryer, 3'15" dia. x 20' long.

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1—3500 gal. T316 SS, jkt. & agit.
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1—1300 gal. T304 SS, jkt., 5 HP XP agit.
3—750 gal. T304 SS, jkt. & agit.
1—500 gal. T304 SS, jkt. & agit.
6—465 gal. T304L SS, jkt. & agit.
1—350 gal. T304 SS, jkt. & agit.
2—125 gal. T316 SS, jkt.

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1—11' x 155' Traylor, 7/8" shell Kiln.
3—10' x 80' rotary dryers, 3/4" shell.
1—9' x 100' Vulcan, 5/8" shell Kiln.
1—8' x 125' Kiln, 5/8" shell.
2—7'6" x 100' 1/2" shell Kilns.
1—7'6" x 60 Kiln, 1/2" shell.
4—Hardinge 8'8" x 70' dryers, 5/8" shell.
1—7'6" x 60' dryer, 1/2" welded shell.
1—Allis-Chalmers 7' x 50' dryer, 5/8".
1—6' x 50' Louisville dryer.
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2—Stainless dryers: 4'6" x 12', 3' x 10'.

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1—8000 gal. T304 SS, vert.
12—4500 gal. nickel-clad, vert. 125#.
1—3000 gal. alum., vert., open.
1—10,500 gal., T304 SS, horiz., UNUSED, dished heads.
2—5700 gal. T304 SS, horiz., UNUSED.
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1—2000 gal. T316 SS, hopper.
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1—3,500 gal. Struthers-Wells vert., 7' dia. x 12' high, jacketed, int. coils, 40/20 HP agit.
1—2,830 gal. horiz. still kettle, 6' x 12' 100 sq. ft. int. coil.
2—2,250 gal. vert., 7' dia. x 6'3" high, jacketed, 3 HP agit.
1—2200 gal., 6'6" x 8', vacuum, jacketed, agit. T316 SS.

TYPE 316 STAINLESS STEEL TANKS

1—17,650 gal. horiz., 9' dia. x 36' long, 1/4" shell, 3/8" dished heads.
1—2,830 gal. horiz., 6' x 12', 5/16 shell & dished heads, VACUUM.
3—2,750 gal. vert., 7' x 8', dished heads, int. coils.
9—2,300 gal. vert., 7' x 8', int. coils, (some w/agit).
5—2,250 gal. vert., 7' x 6' 3", dished heads, (some w/agit., some w/jacket).
2—1,900 gal. vert., 6' x 8', 3/8" shell & dished heads, VACUUM.
4—1,200 gal. vert., 5' x 7', dished top, cone bot., VACUUM.
6—685 gal. vert., 3' x 13', internal coils.
1—575 gal. vert., 4' x 6', dished heads, int. coil.
7—560 gal. vert., 3'6" x 7', dish top, cone bot., VACUUM.
50—Tanks & pots, 30 to 500 gal., T316 SS.

COLUMNS—STAINLESS STEEL

1—110" dia. Vulcan, 10 trays—bubble caps, T316 SS.
2—96" dia. Vulcan, 30 trays—bubble caps, T316 SS.
1—96" dia. Vulcan, 10 trays—bubble cap, T316 SS.
2—60" dia. Vulcan, 10 trays—bubble caps, T316 SS.
1—48" dia. Vulcan, 25 trays—bubble caps, T304 ELC SS, 100 PSI.
3—24" dia. Vulcan, 12 trays—bubble caps, T316 SS—VACUUM.
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5—Steel Packed Columns: 60", 48", 36", 30", 20".

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5—Vulcan copper bubble-cap columns, VACUUM! 72" x 40 plate; 48" x 25 plate; 48" x 22 plate; 24" x 20 plate.

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2—Stainless steel bucket elevators, 60' & 40' high.
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1—Allied Steel Products type 316 SS jacketed reactor, 750 gal.
3—Type 316 SS 150 gal. jacketed reactor, complete with agitator and drive
1—Steel & Alloy Tank Co. 100 gal. type 347 SS pressure tank, 250 psi jacket
1—Blaw-Knox 400 gal. steel jacketed autoclove, 570# internal pressure, 85# jacket
1—Blaw-Knox 45 gal. jacketed autoclaves, 1500# pressure
1—Pfaudler 500 gal. glass lined jacketed reactor, complete with impeller type agitators, baffles and drives
1—Struthers Wells 500 gal. nickel jacketed reactors
1—Patterson-Kelley 6000 gal. steel jacketed reactor, 40# jacket complete with agitator and drive.
1—Patterson 2000 gal. steel jacketed reactor
28—30,000 gal. steel vertical storage tanks

DRYERS

1—Link Belt steel roto louver dryer, Model 1003-30
3—Link Belt steel roto louver dryers, Model 207-10, 310-16, 604-20
1—Buflovak double drum dryer 42" x 120"
3—J. P. Devine single door vacuum shelf dryers, 20, 17 and 12 shelves
4—Stokes Model 138J-20 single door vocuum shelf dryers, 20 shelves, complete
1—Stokes stainless steel rotary vacuum dryer, 2' x 6'
1—Stokes Model 59DS steel rotary vacuum dryer, 5' x 30'
1—Stokes double drum dryer, 5' x 12'
1—Louisville rotary steam tube dryer, 8' x 45'
2—Louisville SS rotary dryers, 8' x 50'
1—Louisville SS rotary kiln, 30" x 28', complete
1—Louisville rotary dryer, 38" x 40', Type L
1—Ruggles Coles 4' x 30' rotary kiln
1—Traylor 4' x 40' rotary dryer
1—Rotary dryer, 6' x 36'

FILTERS

3—Dorrco rubber covered filters, 6' x 2'
1—Sweetland #3 stainless steel filter
1—Niagara SS filter, Model 510-28
1—Oliver horizontal filter, 3'
10—Shriver plate ond frame filter presses, 12" to 42"
1—Shriver rubber lined filter press, 36" x 36"
12—Sweetland #12 Filters with 72 SS leaves

CENTRIFUGES

1—Tolhurst SS 20" suspended type centrifuge with perforated basket, complete with plow and motor
1—AT&M 26" suspended type centrifuge with SS perforated basket, complete with plow and motor
1—AT&M 48" SS suspended type centrifuge, complete with plow, motor and imperforate basket
1—Bird type 316 SS centrifuge, 32" x 50"
4—Tolhurst 30" center slung rubber covered centrifuges with perforated baskets and motors

THE GELB GIRL—NOVEMBER 1959

MIXERS

15—Robinson type 304 SS horizontal blenders, 255 cu. ft. each
3—Robinson type 316 SS sigma jacketed heavy duty mixers, 400 gal.
1—Baker Perkins Size 6, double arm vacuum mixer, 2¼ gal. cap.
1—12' x 4' type 316 SS pug mixer
1—Patterson type 347 SS jacketed vacuum sigma kneader master, 500 gal.
1—Baker Perkins Size 16, Type UUEM 150 gal. jacketed double arm dispersion type mixer, complete with compression cover and 100 HP motor.

MISCELLANEOUS

1—Cleaver Brooks 500 HP package steam generator, 200#
1—Ames 300 HP package steam generator, 150#
2—Cleaver Brooks package steam generators, 50 & 80 HP, 125#
2—Heat Transfer Products steel bubble cap columns, 36" and 42" with 5 and 10 trays
1—Acme steel bubble cap column, 42" dia. with 10 trays
2—Patterson-Kelley steel heat exchangers, 1000 sq. ft. each
6—Struthers Wells heat exchangers, 885 sq. ft.
1—Patterson-Kelley steel heat exchanger, 427 sq. ft.
50—Steel heat exchangers from 15 sq. ft. to 400 sq. ft.
25—Davis engineering SS heat exchangers, 145 sq. ft. and 230 sq. ft. (NEW)
1—Struthers Wells type 316 SS heat exchanger, 330 sq. ft.
2—Condenser Service type 316 SS heat exchangers, 350 sq. ft.
3—Badger type 316 SS heat exchangers, 500 sq. ft. and 600 sq. ft.
1—Badger type 316 SS bubble cap column, 42" dia. with 11 trays
1—Badger type 316 SS bubble cap column, 36" dia. with 8 trays
1—Vulcan SS bubble cap column, 4' x 28 plates
3—Robins shaker screens, SS, 3' x 6'
1—Swenson type 316 SS vacuum crystallizer, 3' 6" x 12'
1—Swenson type 316 SS vacuum crystallizer, 2' x 12'
1—Blaw Knox steel distillation column, 36" x 40' w/24 trays (NEW)
3—Williams type 316 SS hammermills, Model AK
1—Stokes Model T tablet press
1—Swenson SS pilot plant spray dryer

2—Sturtevant #7 SS dust type rotary batch blenders, NEW
1—Oliver SS rotary vacuum filter, 12" x 18"
1—18,000 gal. stainless steel pressure tank, 60 psi
3—Oliver SS rotary pressure precoat filters, 5'3" x 8'

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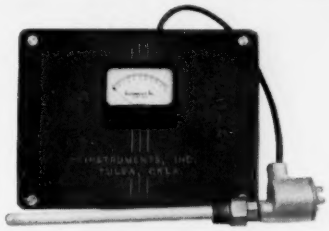

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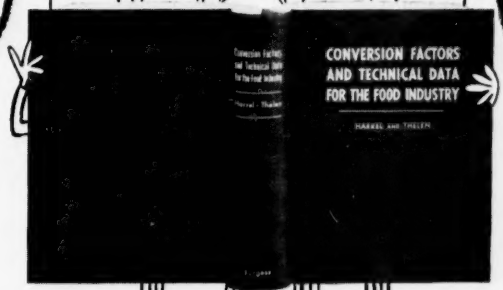

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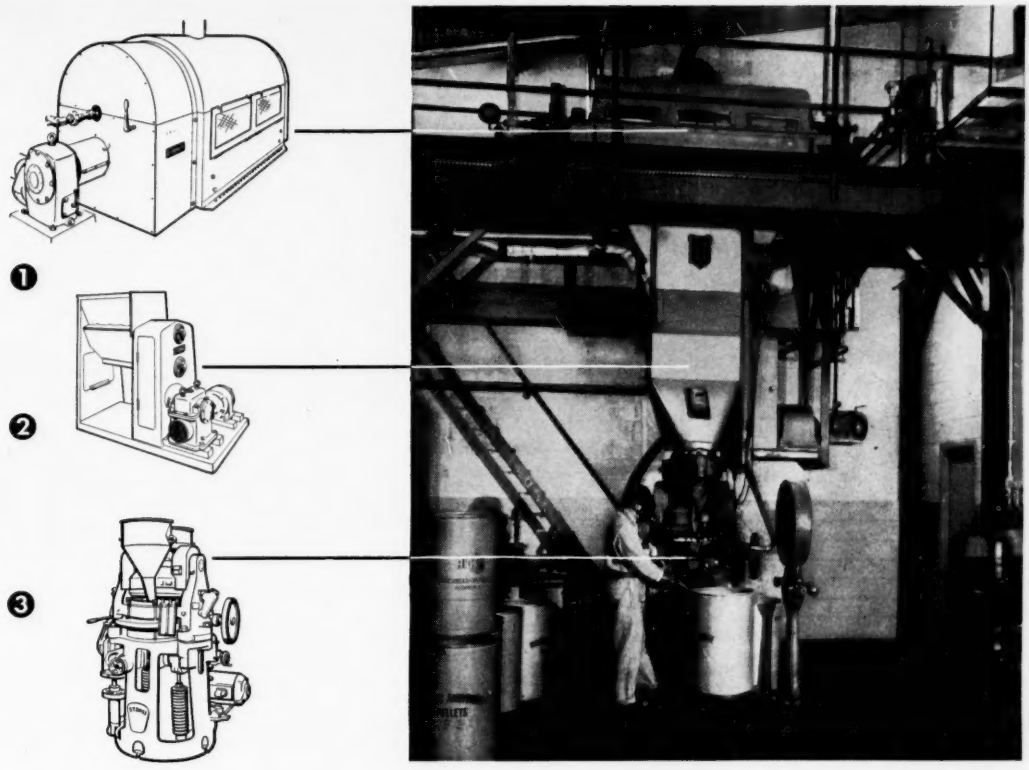

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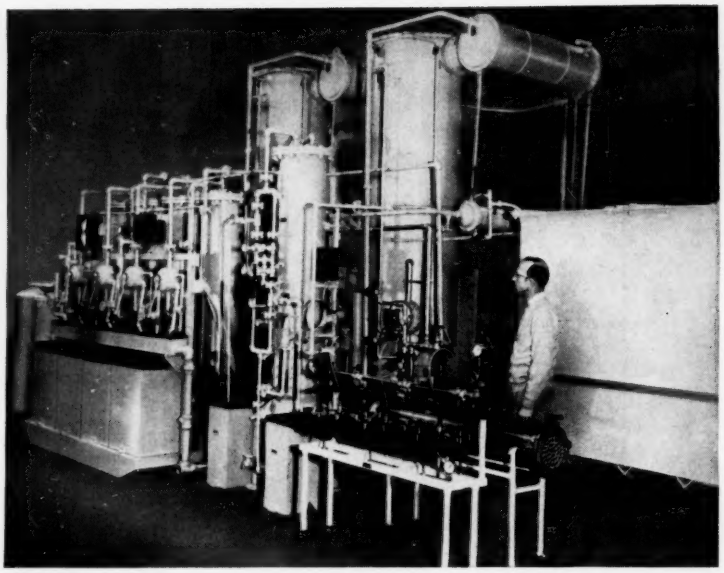

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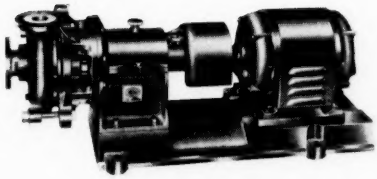

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